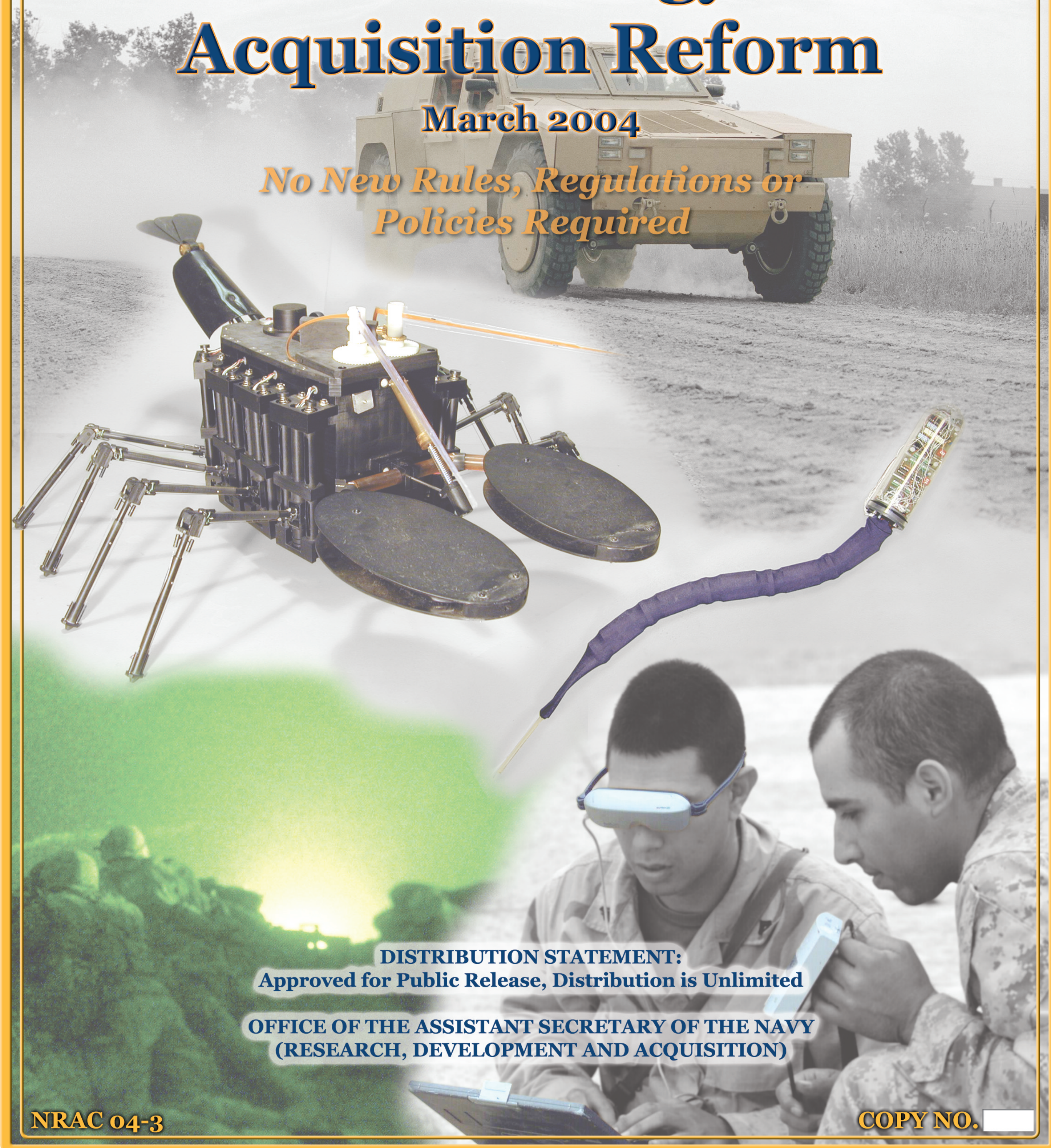
Naval Research Advisory Committee Report

Technology Acquisition Reform

March 2004

No New Rules, Regulations or Policies Required



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14. ABSTRACT

T he acquisition system used by the Department of the Navy (DON) to procure new systems including software and material is mandated by the Department of Defense (DoD). The goal of the acquisition system is to insure that DON personnel have the best and most reliable hardware and software available to accomplish assigned missions. However, because of the complexity of modern day warfare, rate of change of technology, bottom line emphasis by commercial business, as well as regulatory restrictions both internal and external to the DoD, the acquisition system has become cumbersome and excessive. Accordingly the Assistant Secretary of the Navy (Research, Development and Acquisition) tasked the NRAC to examine current approaches to managing DON acquisition programs with a particular emphasis on technology acquisition. Specifically, the Panel was asked to recommend procedures and opportunities to streamline and improve technology acquisition subject to regulatory restrictions.
The Panel found that there was no one item that in and of itself would reform acquisition. They did identify and discuss in detail six different areas that had the potential to streamline acquisition. More importantly, the Panel felt that the procedures could all be enacted with no new laws or regulations.

15. SUBJECT TERMS

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Naval Research Advisory
Committee Report

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Executive Summary

In February 2003, the Naval Research Advisory Committee was charged by Mr. John J. Young, Jr., Assistant Secretary of the Navy (Research, Development and Acquisition) to conduct a study on technology acquisition reform. The major difference between this study and others on acquisition reform is that this study focuses on ways to more smoothly inject new technology into acquisition programs.

The Department of the Navy wants—and needs—to exploit technological advances more rapidly. The ability to field technologically sophisticated systems and use them effectively is a distinctive asymmetrical advantage the United States enjoys over its adversaries, and anything that increases our rate of innovation—whether the innovations originate in government, industry, or abroad—works to the advantage of our Sailors and Marines.

But this challenge can be frustratingly difficult to meet. Persistent problems stand in the way. Cultural, bureaucratic, and programmatic obstacles bedevil the acquisition of technology. The culture that surrounds the acquisition system makes it difficult to bring new technology into that system. This system remains very conservative: structured to avoid fraud, conflict of interest, and risk, it discourages the research and development community from taking risks and seizing opportunities. Designed to eliminate risk and meet cost and schedule constraints, the system rightly treats unproven technology as a risk to its programs. Whether the acquisition consumer of technology is a Naval Program Manager or a contractor, that consumer is disinclined to accept risky new technology (however high the payoff it promises) for fear of failure (and the results of failure).

Implicit in Sea Power 21 is an imperative to speed development of new concepts and technologies and to streamline the procedures that facilitate their rapid implementation. The six recommendations of this study, listed below, will shorten the time required to respond to the warfighter's needs.

Institutionalization of a Rapid Technology Acquisition Team concept would establish an ability to respond rapidly to the warfighter's unique and immediate needs, bypassing the more deliberate acquisition process. The approach would insure that logistical support is provided and maintained for items delivered through this accelerated process.

Similarly, a Direct Reporting Program Office for Disruptive Technology would incubate promising technologies until they are ready to be handed over to an established program. This office would also provide a home for disruptive technologies emerging from discovery and invention. Since these potentially transformational technologies are not linked to existing acquisition programs, they need an alternative path to maturity.

Requiring a science and technology project, whether or not it directly supports a Future Naval Capability, to identify an acquisition advocate when it reaches Technology Readiness Level (TRL) 3, and to have a signed Technology Transition Agreement at TRL 4, will facilitate a more rapid maturation and acceptance of technology. It would focus resources on science and technology that have a customer, and it would give the customer responsibility

for program oversight beyond TRL 4. The net result should be a higher yield from the science and technology program.

Using established metrics and TRLs to measure a technology's readiness for insertion into acquisition programs would improve the chances of program success. Not only will specific programs benefit, but the consumer's confidence in science and technology will also increase, to the general improvement of the research and development culture. Contractual and personnel incentives to temper risk aversion and encourage technology insertion should further improve the maturation and infusion of technology. The synergy of these initiatives will encourage proper assumption of well-managed risk to meet the needs of the Fleet and Force.

The test and evaluation process is often described as a principal obstacle to rapid handover of technology from acquisition community to the warfighter. In order to be most efficient and effective, the test and evaluation process must complement evolutionary acquisition and spiral development. An additional study is recommended to determine ways to better accomplish test and evaluation.

A technology knowledge base is essential and should be established. The acquisition customers' program is best served if a repository of technology development efforts were available to improve identification of candidates for technology insertion, which in turn may accelerate delivery of mature technology to our Sailors and Marines.

Terms of Reference

This NRAC study will examine current approaches to managing DON acquisition programs with a particular emphasis on technology acquisition. This study will also examine alternative approaches tested by other departments, agencies, and countries. Specifically, this NRAC study will:

- Review examples of new, emerging, and experimental technology acquisition. For example, NMCI lessons learned, CTTO lessons learned, In-Q-Tel, Army venture fund, DoD and Navy venture fund plans, UK R&D privatization.
- Investigate acquisition alternatives studied by USD(AT&L), and others.
- **Recommend procedures and opportunities to streamline and improve technology acquisition subject to regulatory restrictions.**

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The panel emphasized identification of actionable and unique recommendations to enhance technology acquisition for:

- Timely anticipation of, or response to, both traditional and asymmetric threats,
- Responsiveness to the needs of the acquisition community—the primary consumer of science and technology's products, and
- Effective delivery of war fighting capability to maintain our technological advantage.

The full text of the Terms of Reference is in Appendix A.

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Panel Participants

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Years of Experience					
Operational	Program Management	Technology Development	Acquisition Workforce	Industry	Government
84	105	82	87	71	252

SPONSOR
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Executive Secretary
W.Page Glennie

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The Panel's members brought a rich and robust experience based in several critical areas that impact technology acquisition. This panel contained deep operational expertise, diverse program management experience, significant technology development knowledge, and major acquisition acumen. It is also noteworthy that these experiences stem from both industry and government perspectives.

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Fact Finding:

Briefings and Visits

United Kingdom Trip:

- MoD - Public Private Partnership
- DPA - S&T Acquisition Strategy
- DSTL - Overview of changes in research and acquisition
- QinetiQ - Transition from DERA to QinetiQ
- Rolls Royce - Corporate Technology Acquisition

Other Discussions & Briefings Reviewed:

- Commercial Technology Transition Officer
- Executive Director, SPAWAR Systems Center
- FNC Brief to DASN(RDT&E)
- CNR Corporate Brief
- GAO Report on Technology Management Best Practices
- OSD Brief on Transitioning S&T Programs
- OSD Management Guide to Technology Transition
- Air Force Brief on Applied Technology Council
- Army Brief on Technology Transition Workshop Assessments & Recommendations

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The Panel conducted a series of fact-finding meetings to gain Naval, Defense, Industry, and Congressional perspectives.

The Panel also visited the United Kingdom, where it conducted particularly useful interviews with senior representatives of the United Kingdom's defense research and development community. These British officials had particularly valuable insights into the privatization of research and development.

Finally, the Panel conducted other discussions and gathered other material as needed.

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Fact Finding:

National Defense University Research

- **NDU research library conducted a broad search of recent studies (1997 to present) on technology acquisition**
  - **DoD: DSB, other DoD**
  - **FFRDC: CNA, RAND, IDA**
  - **Congress: GAO, CRS, CBO**
- **Conclusions and recommendations were reviewed by the panel**

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The National Defense University's research librarians conducted a broad search of recent (since 1997) studies of technology acquisition. They found relevant studies from a wide spectrum of the defense community:

- Department of Defense: Defense Science Board, Office of the Secretary of Defense Inspector General, all three Service Departments;
- Federally Funded Research and Development Centers (FFRDCs): Center for Naval Analyses, RAND Corporation, Institute for Defense Analyses, Carnegie Mellon University Software Engineering Institute;
- Congress: General Accounting Office, Congressional Research Service, and Congressional Budget Office.

The research librarians summarized the studies' conclusions and recommendations for the panel. The Panel reviewed the summaries to establish a baseline of knowledge derived from the work of other expert teams, thus avoiding duplication of effort and gaining insight from other studies. Several of the sources the National Defense University located bear directly on Naval technology acquisition.

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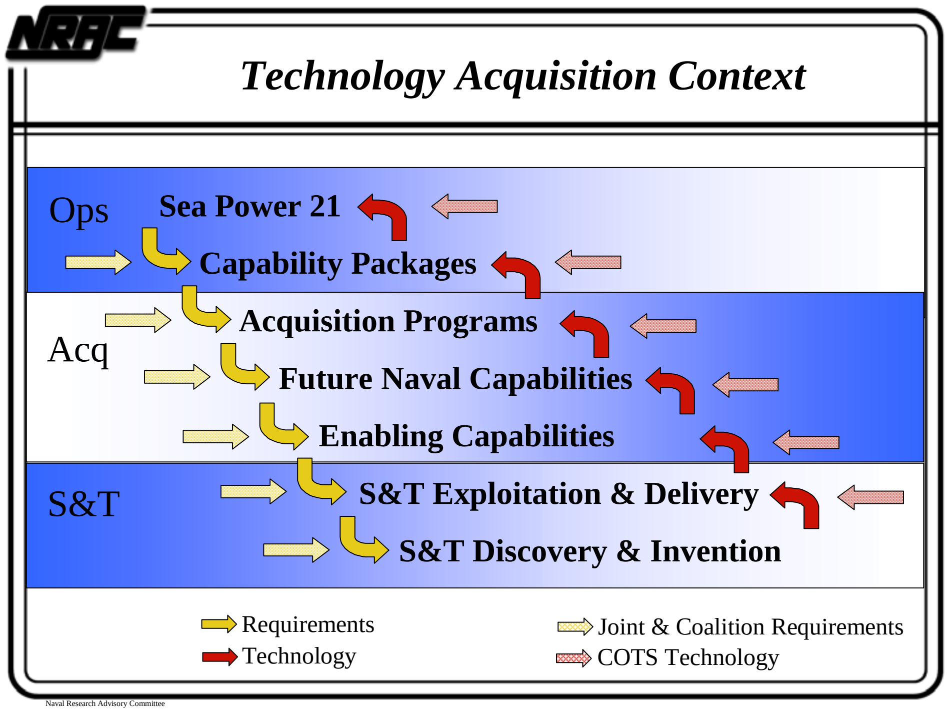


A continuum runs from desired operational capabilities to the basic science that will provide warfighters with enhanced future capabilities.

Technology ought to serve some useful end. This should be obvious, but the frequency with which one sees technologies pursued with no apparent operational end in view indicates that it is not. The Naval process for technology acquisition recognizes this in its emphasis on requirements flowing down from the operators to the Program Managers (PM), engineers, and scientists, to be met with capabilities flowing back up through the acquisition system. Conceptually clear and well structured, this system is in fact riven by seams. We see these open between the operators and the resource sponsors, between the resource sponsors and the acquisition community, and between the acquisition community and the science and technology (S&T) community.

To achieve mission success all *constituent communities* must work together seamlessly. As requirements flow from the *operational community* to ultimately drive S&T investments, we need *technology* to flow into operations in order to maintain our warfighters' technological advantage.

So far this is a purely Naval view, but Naval operations are normally conducted jointly with other services or in coalition with allies. These bring *additional requirements* that further complicate matters. At the same time rapidly accelerating advances in commercial technology need to be *integrated* to give our warfighters further technological advantages.

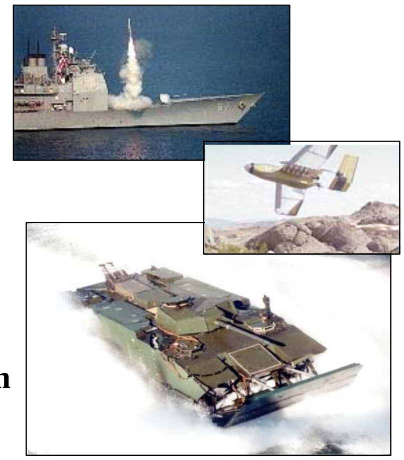
The Panel believes its recommendations, if adopted and acted upon, will strengthen communications among these communities. They will also further build confidence that the

S&T community can deliver technology at the speed and maturity required by the acquisition community to field winning technological advantages for our warfighters.

Challenge: ***More rapidly exploit government and commercial technology advances***

Confounding Issues:

- **Cultural environment**
- **Bureaucratic barriers**
- **Programmatic issues**
- **Inconsistent incentives**
- **Accelerating technology development cycle**
- **Technology transition from S&T to Acquisition: "Valley of Death"**



Goal: *Maintain Technological Advantage*

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The Department of the Navy (DON) wants—and needs—to exploit technological advances more rapidly. The ability to field technologically sophisticated systems and use them effectively is a distinctive asymmetrical advantage the United States enjoys over its adversaries, and anything that increases our rate of innovation—whether the innovations originate in government, industry, or abroad—works to the advantage of our Sailors and Marines.

But this challenge can be frustratingly difficult to meet. Persistent problems stand in the way. Cultural, bureaucratic, and programmatic obstacles bedevil the acquisition of technology. The culture that surrounds the acquisition system makes it difficult to bring new technology into that system. This system remains very conservative: structured to avoid fraud, conflict of interest, and risk, it discourages the research and development community from taking risks and seizing opportunities. Designed to eliminate risk and meet cost and schedule constraints, the system rightly treats unproven technology as a risk to its programs. Whether the acquisition consumer of technology is a Naval PM or a contractor, that consumer is disinclined to accept risky new technology (however high the payoff it promises) for fear of failure (and the results of failure).

The S&T part of the research and development community has shown the obverse of this problem: a tendency to work on technology for its own sake, without proper attention to risk mitigation or realistic operational needs. Despite efforts toward cultural change across the research and development community, both syndromes persist.

Bureaucratic obstacles and programmatic barriers can retard the pace of advance. Incentives are available—and more have become available with recent reforms—to move technology forward into acquisition, but such incentives are applied inconsistently and often fail to achieve their intended result. Presently, few programs have built-in contract incentives for

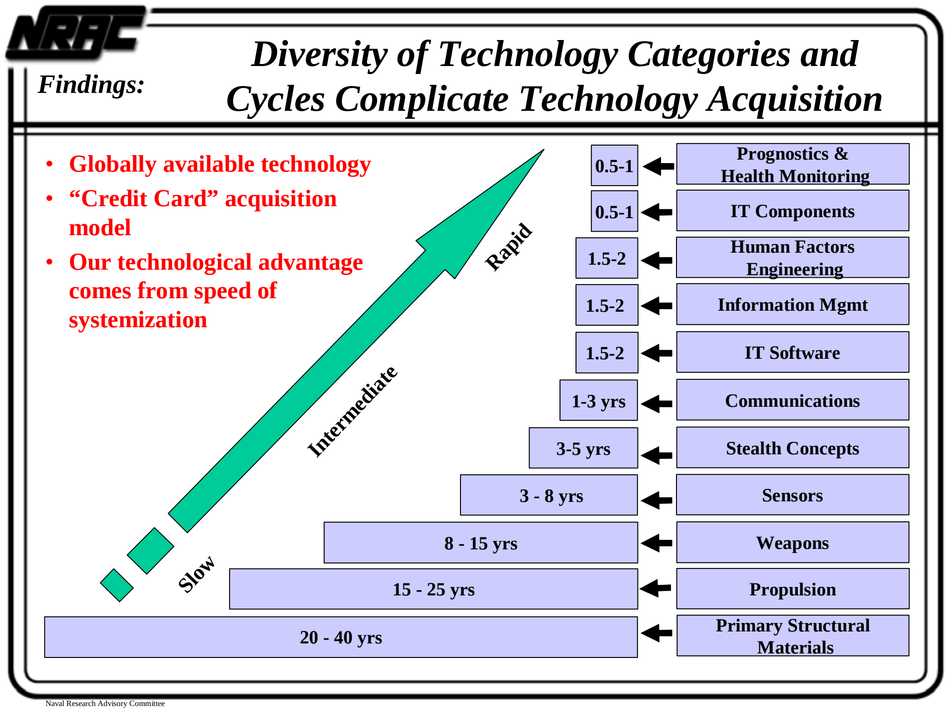
the contractor to insert new technology in a reasonable cycle, and even fewer programs offer the acquisition work force incentives to pull new technology into a program. This amounts to a large barrier in the path of technology acquisition.

Our acquisition system is so vertical, and relies so heavily on consensus-building that one negative vote can kill a good initiative. Comptrollers in particular often interfere with budgets that allow for technology insertion by sweeping up cost savings from new technologies to fund shortfalls in other programs. The rigidity of the Planning, Programming, and Budgeting System (PPBS) also inhibits the introduction of new technology that appears off-cycle from the Program Objective Memoranda (POM) and Future Years Defense Program (FYDP) planning cycles.

Technology itself is advancing at an increasing rate, and we have not been as successful as we might in bringing the latest advances into fielded systems. Technology matures at various rates and in different cycles. Moore's Law, for example, continues to govern the computer industry, which now cycles at a rate of about eighteen months.[1] By way of contrast, propulsion technology tends to undergo major changes every fifteen to twenty-five years. With the increased global availability of new technology, and the push of United States industries to move more rapidly to market, several of the longer cycles of technology change are getting shorter. Since much of our advantage lies in our ability to work new technology into systems, to stay ahead of our adversaries we must infuse new technology more rapidly.

Finally, Naval research and development still suffer from a "Valley of Death" in which potentially promising new technologies languish and die. This gap between S&T on the one hand and acquisition on the other has narrowed, especially in the Future Naval Capabilities (FNC) process, but it nevertheless persists to some degree. The panel believes that the Valley of Death is a self-inflicted wound that could be closed through more closely coupled transition mechanisms informed by the discipline of Technology Readiness Levels (TRLs).

[1] Moore's Law states that the number of transistors that can be placed in a production integrated circuit doubles roughly every eighteen months.



Consider this graphic representation of technology development cycles. All these technology categories presently advance at an increasing rate—none is mature or stable. Because new capabilities are increasingly available globally, many of our adversaries have moved to a credit-card acquisition model—they simply buy whatever they find they can make use of. Our national advantage in using technology comes from our ability to integrate new technologies into systems rapidly. (Having said this, there is also no reason why we should deprive ourselves of credit card acquisition when we can use it to good effect.)

Note that many of these categories have cycle times significantly shorter than the customary seven- to ten-year system acquisition cycle. This means that PMs must provide for technology insertion *during* system development, as well as over the system's service life.

Complex systems involve subsystems and components that draw from many categories of technology. We need processes and system designs that provide the ability to change out obsolete elements to maintain system-level performance without undue cost or system down-time. Obsolescence theory would help us better understand and predict when subsystems and components have reached this level. QinetiQ is beginning to do this in the United Kingdom. We should explore QinetiQ's approach to developing better replacement strategies to counter obsolescence.

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Findings:

Many Factors Affect Technology Acquisition

- **GAO concludes that maturing technology prior to acquisition correlated with success**
- **Programs lack consistent process to find technology opportunities**
- **PMs and industry are not typically or consistently incentivized to find and transition technology**
- **Parallel testing against mission capabilities not commonly practiced**
- **Best design practices facilitate rapid technology acquisition**
  - **Modularity & partitioning designs**
  - **Open systems**
  - **Open software**
  - **Modeling & simulation**
  - **Middleware**
  - **Application program interfaces**

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In 1999 a General Accounting Office study found a strong correlation between technological maturity (at the point of a technology's insertion) and the success of acquisition programs.[2] Having achieved a high TRL is certainly not a guarantee of program success, but the correlation is too marked to be ignored.

The panel also found that acquisition programs within the DON have no consistent ability to find, catalogue, and assess technological opportunities. This problem is compounded by a general failure to give PMs and contractors consistent incentives to enhance their programs with new technologies. We note that such incentives are available, but we find that they are not being consistently applied. And lastly there is a growing frustration on the part of program personnel and financial officials with the time and expense of apparently duplicative testing. They feel such testing substantially delays the introduction of new technologies.

The panel found a variety of design practices that appear to facilitate rapid technology acquisition. These include modularity and partitioning, open systems, open software, modeling and simulation, middleware, and application program interfaces.

[2] GAO Draft Report dated 7 June 1999 (GAO Code 707336) OSD Case 1836, *Best Practices: Managing technology development can improve weapon system outcomes*.

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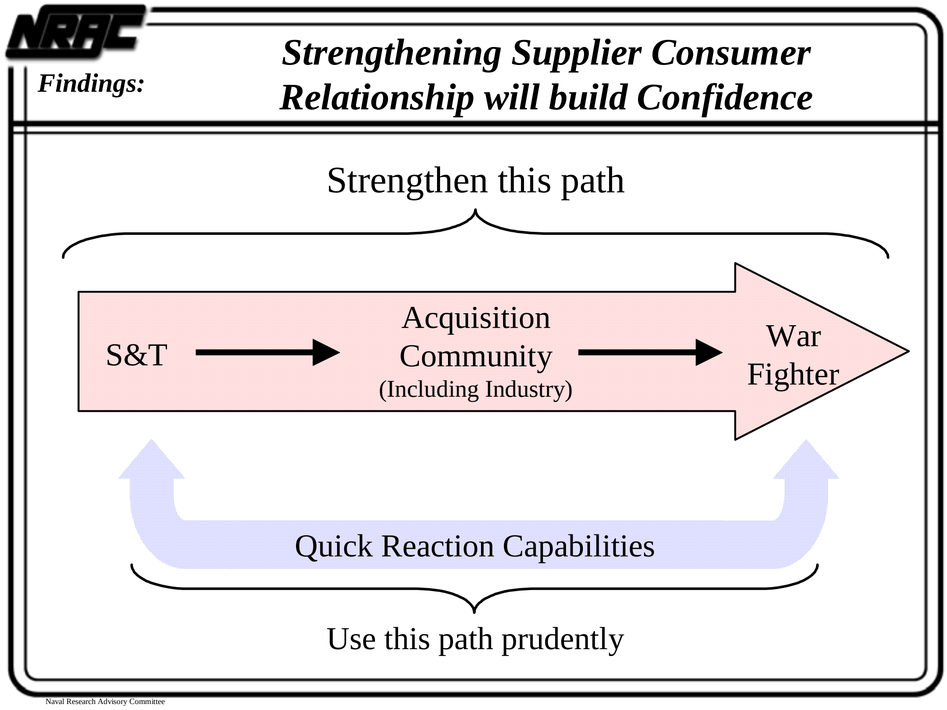


Technological innovation is usually the outcome of scientific inquiry. Within the DON, S&T is the responsibility of a distinct community within the research and development establishment. The Panel believes that the S&T community has not, despite its efforts, correctly identified its principal customer. While the warfighter is the ultimate user of the product, science and technology normally finds its way to the warfighter through some acquisition program. Paradoxically, the S&T community's focus on the operating forces may actually be retarding development of the tools the Fleet and Force need.

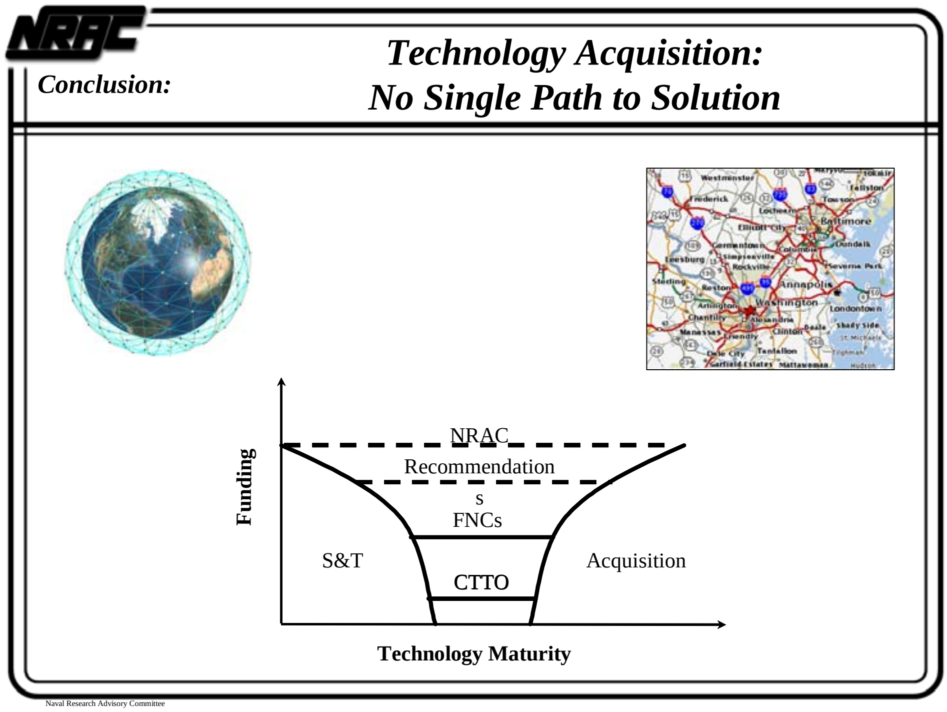
In general, the acquisition community lacks full confidence that the S&T community is meeting its needs by developing the right technology to the level of maturity necessary for insertion into programs of record. The warfighters see a mixed picture. Ships are often delivered with out-of-date capabilities. Yet efforts to field innovative systems and capabilities rapidly are sometimes poorly thought-out, particularly with respect to their support once fielded, instead of providing capable, reliable, technologically advanced equipment, the user ends up with "magic junk."

The Panel argues therefore that the principal customer of a S&T program should be an acquisition program. We think that this will tend to shorten the normal path from S&T to fielded capabilities. The occasions when the warfighter is a direct customer are the exception—normally, an operational commander gets technology through the acquisition process. So while there should be paths directly between S&T and the Fleet and Force, these should be used sparingly.

In special cases Advanced Concept Technology Demonstrations, (ACTDs), for example) we bypass the normal acquisition process. ACTDs place innovative new technologies in the hands of an operational sponsor, permit them to be evaluated in a realistic opera-

tional environment, and leave residuals in the field with the operating forces (unfortunately sometimes without adequate logistical support). There are also situations in which commanders recognize emergent needs and communicate these to the S&T community (through, for example, their Naval Research Science Advisors, or a Marine Corps' Urgent Needs Request). Although these exceptional pathways should be used judiciously, they nonetheless remain valuable routes through which new technologies reach the Fleet and the Force.

In sum, the science and technology community should regard the acquisition community as its primary customer. At TRL 3 and above, S&T projects should have an identified acquisition customer who not only wants the project, but is willing to work in partnership to mature the technology. We think this customer should normally be a PM. The acquisition community must understand that the S&T community is its technology supplier, and that the warfighter is in turn its ultimate customer. The warfighter needs up-to-date systems that work, and that our Sailors and Marines can use. This Panel's recommendations are aimed at strengthening these important links.



Recognize at the outset that there need be no single path to a solution. The panel believes that in fact there are multiple ways of closing the "Valley of Death." Just as communication networks route traffic opportunistically through various paths, just as roadways afford multiple routes to a destination, so too technology can move in many ways from the laboratory to a fielded system.

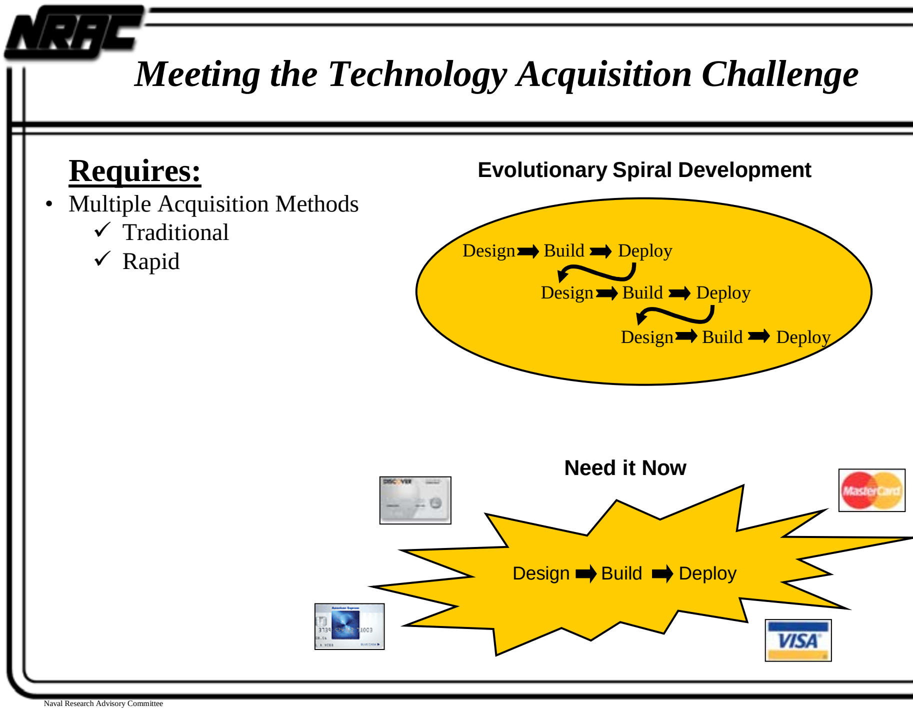
The Commercial Technology Transition Office (CTTO) in the Office of Naval Research moves certain technologies across the Valley (and its "deals"—and the methods used to broker them—merit greater emphasis). FNCs also represent a good start towards bringing valuable technologies into the acquisition system.

The 1999 General Accounting Office study that found a strong correlation between TRL and acquisition program success recommended that S&T programs reach TRL 6 before transition to acquisition. The Department of Defense (DoD) concurred with this recommendation, but has not fully implemented it. The experience of the FNCs indicates that most Technology Transition Agreeements (TTAs) are negotiated so that the S&T community brings its products to TRL 6, at which point the acquisition community picks them up.

We think that proper attention to TRLs, and a closer coupling of the S&T community with the acquisition community, form the basis for multiple paths to transition. We will report our recommendations in detail below, but in brief we think the four principal ways to close the Valley of Death are:

- CTTO++ (with emphasis on making more deals)
- FNCs++ (with tighter TTAs, and fewer projects to better achieve a critical mass of funding)

- Closer coupling of *all* S&T programs with acquisition programs at TRLs 3 and 4.
- Rapid Technology Acquisition Teams.



We propose several changes in the current acquisition process to address the issues raised earlier. The first relates to the creation of Rapid Technology Acquisition Teams (RTAT) to provide an alternative, fast, design-build-deploy process. Various relatively small, sometimes *ad hoc*, programs do that now (ACTDs, the Naval Fleet-Force Technology Innovation Office, for example), but we propose an over-arching, institutionalized Naval process to capture those exceptional but crucial occasions when a breakthrough or an emergent need offers an opportunity for fast, effective technological support of the warfighter.

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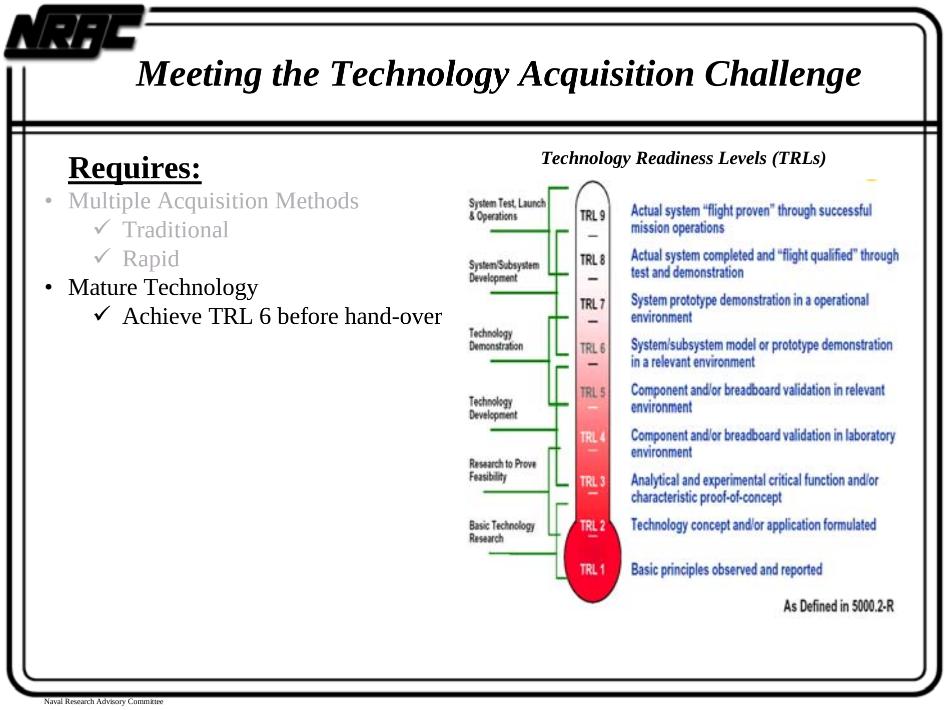

A technology's maturity can be measured, and its development managed and tracked. The most accepted method uses TRLs as a principal tool.

Tying S&T program decisions and management to these TRLs would usefully inform decisions regarding continuation or handover of science and technology programs. Evidence also shows a high correlation between program success and the maturity of its technologies before they are incorporated into the program. TRL 6 has come to be a generally accepted level of maturity for handing over a product from science and technology to acquisition. While DoD 7000.14-R places responsibility for achieving TRL 6 in Budget Activity 4 (Advanced Component Development and Prototypes), we note that the FNCs have generally negotiated TRL 6 as the handover point from S&T to acquisition.

The second suggested change is to provide oversight of the S&T budget related to maturing technology from TRL 4 to TRL 6, and thence into acquisition programs. This is the intent of the FNCs, but the FNCs appear too diluted. (This dilution is ironic, since one of the main reasons for setting up the FNCs in the first place was to concentrate resources on crucial technology gaps in order to achieve the critical mass necessary for transition.) Fixing this will require acquisition to identify key new technologies, provide paths to incorporate them into actual acquisition programs, and stimulate some demand-pull.

(See Appendix B for a definition of TRLs.)

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Meeting the Technology Acquisition Challenge

Requires:

- Multiple Acquisition Methods
  - ✓ Traditional
  - ✓ Rapid
- Mature Technology
  - ✓ Achieve TRL 6 before hand-over
- Incentives for Technology Insertion

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People and organizations respond to incentives. Properly structured, incentives are a powerful means to create desired behaviors.

PMs tend to be risk averse—the present system tends to punish risk-taking—and new technology inevitably carries risk—especially if it is inserted prematurely. The acquisition community must receive incentives to accept reasonable risk to reap the cost, schedule, or performance benefits of technology insertion. A wide variety of contractual and personnel incentives exist, but have not been consistently applied to this end. The S&T community would also benefit from metrics—like well structured TTAs requiring PM or PEO signature, and properly applied TRLs—that would give them an incentive to seek out opportunities for technology insertion.

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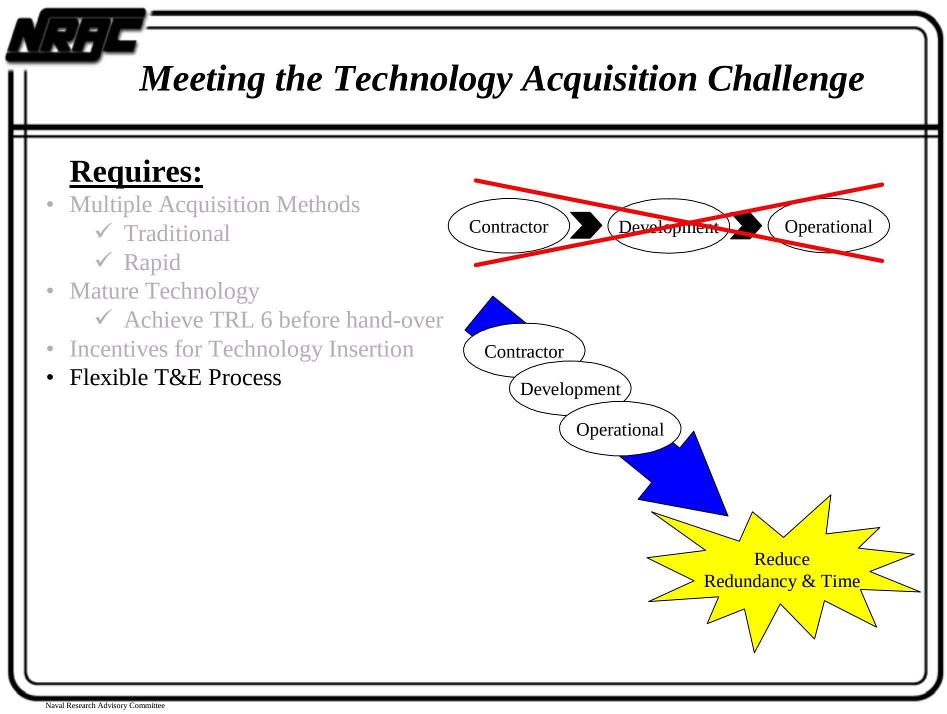

The present test and evaluation process entails initial testing by the contractor, followed by developmental testing under the PM, and concludes with an independent operational evaluation conducted under the guidance of the DoD. For the most part these tests are done in series, with considerable duplication. Very little is done concurrently to reduce redundancy, shorten cycle time, and hold down costs. Considerably more needs to be done in this area. Refining and streamlining all test and evaluation could significantly speed technology to acquisition and thus delivery to the warfighter.

We are convinced that a better-coordinated test and evaluation process will decrease the time it takes to acquire new technology. A detailed treatment of test and evaluation is beyond the scope of the present study, but we strongly suspect, on the basis of what we have learned, that a more flexible test and evaluation process would pay great dividends in swifter insertion of new technology. We believe this merits further study.

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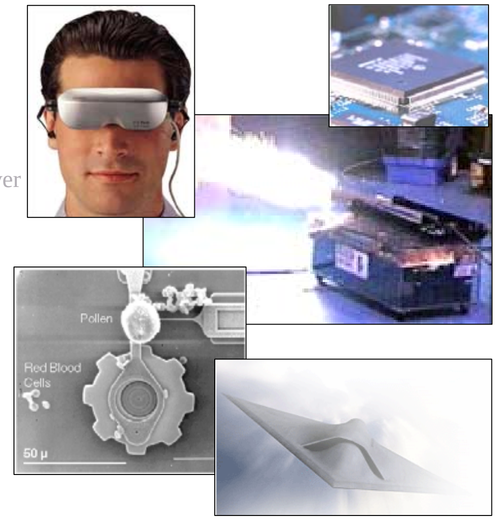
Meeting the Technology Acquisition Challenge

Requires:

- Multiple Acquisition Methods
  - ✓ Traditional
  - ✓ Rapid
- Mature Technology
  - ✓ Achieve TRL 6 before hand-over
- Incentives for Technology Insertion
- Flexible T&E Process
- Visibility of Available Technology



Naval Research Advisory Committee

Finally, the acquisition community, the warfighter, and indeed the S&T community itself need better awareness of available technology. The Office of Naval Research Global and the CTTO both provide some of this awareness, but a comprehensive, accessible knowledge base of Naval S&T (including work from other Defense organizations with Naval applications, other governmental agencies, commercial sources, and international entities) is still needed.

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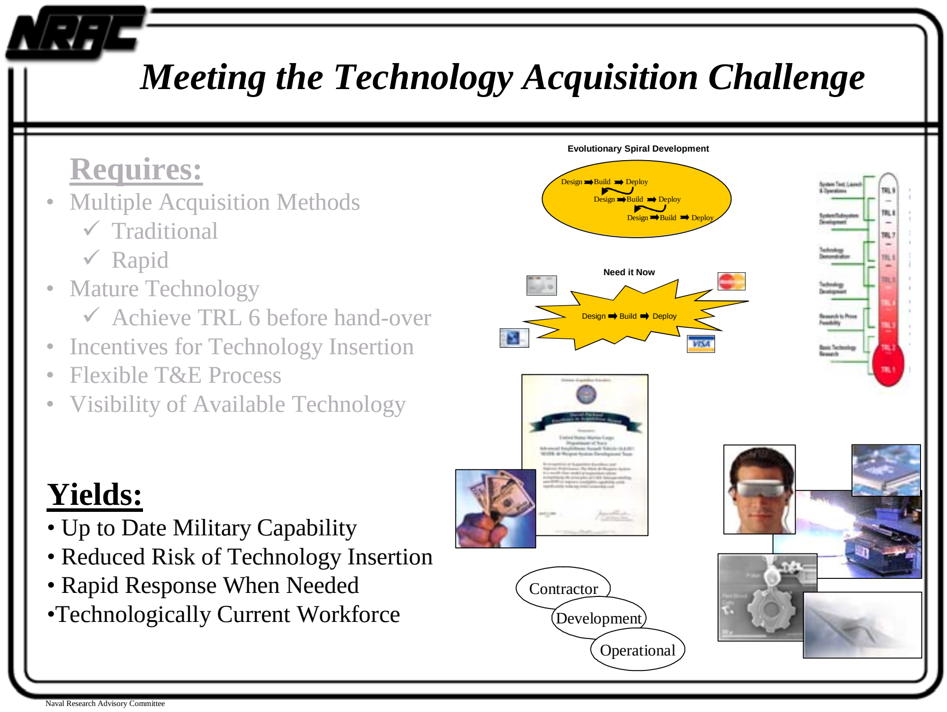

Here is the upshot of our recommendations, if they are implemented. The goal is a Navy-Marine Corps Team with the most advanced, the most agile, and the most affordable technological capabilities possible. We can achieve this by reducing the risk of inserting technology into acquisition programs, by providing rapid response when needed, and by maintaining situational awareness of technological possibilities world-wide.

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Findings & Conclusions:

Rapid Response Needed

- **Certain high priority external demands require a shorter S&T response cycle**
- **Technology base provides unforeseen/unplanned opportunities**
- **Did not find an institutionalized rapid acquisition process across DON**
  - **Did find successful USMC example in their Urgent Needs Request process**
- **Solution space must be bound by time, complexity, funds**
- **Naval Research Science Advisors provide ONR link to Fleet/Force**
- **Program teams need to be integrated with SYSCOMs/PEOs/DRPMs to include engineering and logistical systems**

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The FNC process and its associated time lines have come to form the baseline for technology development and transition within the DON. However, it is also clear that no single process or methodology for technology transition can apply to every circumstance or meet every need. This is particularly true for Naval forces, which, inherently expeditionary as they are, face shifting and complex threats.

A parallel, streamlined process that emphasizes a much shorter response cycle to support selected high priority needs of the operating forces is necessary. These "out-of-cycle" high-priority needs often emerge in response to pre-deployment or contingency work-ups, and imminent or on-going combat operations. Such a rapid response capability would also foster unforeseen and unplanned capitalization of the technology base as the result of "rapid insight" opportunities, associated with the analysis of asymmetrical threats and the need for non-traditional counters.

The DON does not now have a formal, routine, documented method of consistently addressing high-priority demands for rapid technology acquisition (even though history offers many examples of this sort of process occurring on an emergency or *ad hoc* basis—the DON's participation in Team Tango is a recent example).

The Marine Corps does, however, have a documented and functioning Urgent Needs Request process that has worked successfully for several years and could be adapted or form the basis for a Department-wide method.

There are three keys to establishing an effective rapid response capability:

- Define the boundaries of a high-priority initiative. Such an initiative will generally have a limited response time, a short required time-to-market, relatively simple associated technologies to be transferred, and a small to moderate level of investment.

- Establish clear and regular communication among the principal customers (operating forces and the acquisition community) and the primary suppliers (the Office of Naval Research and the Deputy Assistant Secretary of the Navy (Research, Development, Test, and Evaluation)). Such linkages are already partially in place with the Naval Research Science Advisors at all major Fleet and Force commands. Technology liaison positions in the acquisition community would make a major contribution and fill a large gap.

- Insure that teams formed to execute rapid response requests are associated with the appropriate SYSCOM or PEO. This is particularly important to insure that proper system-wide safety and assurance needs are met, and that future logistical life cycle support issues are resolved (in order to avoid the “magic junk” syndrome common in the past).

Recommendations: ***Create Rapid Response Capability***

- **Establish a rapid response process**
  - **Review OSD "Team Tango" and USMC Urgent Needs Request processes for applicability and lessons learned**
- **Create Rapid Technology Acquisition Teams (RTAT)**
- **Use PEO/PM's CTO or "Technology Liaison" as linkage between ONR and acquisition**
- **Assign the responsibility for this process to DASN(RDT&E)**

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The Panel recommends that the Department establish a formal rapid response technology acquisition process and create short-tenured RTAT to accomplish assigned tasks. These interdisciplinary teams would be assembled from both the S&T and acquisition communities, and would exist only as long as the task remained. The Marines' Urgent Needs Request provides a model of how the DON might initiate a RTAT.

The Panel further recommends that SYSCOMs, PEOs, and DRPMs use their Chief Technology Officers (CTOs) as the link between the Office of Naval Research and the acquisition community. For organizations that do not have CTOs or other "tech-finders," billets should be established, immediately staffed, and assigned this and other related responsibilities. The Naval Research Science Advisors who play an analogous role on operational staffs may provide a model of such linkage. Responsibility for establishing and funding this new capability should probably rest with the Deputy Assistant Secretary of the Navy (Research, Development, Test and Evaluation).

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Findings & Conclusions:

Technology Maturity is Key

- **There is a high correlation between technology maturity (TRLs) at insertion and program success**
- **Managing technology to maturity is improved by:**
  - **Identified "consumers"**
  - **Formal agreements**
  - **Technology management more tightly aligned with acquisition program**
- **FNC process has increased likelihood of developing technology to acceptable TRL**
- **Disruptive technologies, which may provide leap ahead capabilities, threaten programs of record**

Naval Research Advisory Committee

The experience of the Panel as well as the General Accounting Office's conclusions strongly suggest that achieving a high level of maturity before new technologies are inserted into product development significantly increases the probability of program success. High levels of technical maturity obviously cannot insure the success of a program but attempting to adopt technology before high levels of maturity have been reached substantially increases risk to a program's cost and schedule. As the General Accounting Office notes in its report on the impact of technological maturity on program success, "It is a rare program that can proceed with a gap between product requirements and the maturity of key technologies and still be delivered on time and within costs."

The Navy's FNC S&T management and alignment process holds promise for addressing the challenge. Important technologies are being matured, and formal agreements between the acquisition community and the S&T community are beginning to foster technology transition. Here are some of the reasons the FNC *process* is showing promise:

- It is aligned with future capability needs and helps to close gaps between the "as is" situation and the future capability requirement,
- The FNCs are reviewed periodically and realigned if necessary with future needs,
- All FNC's are led by an Integrated Product Team composed of the major stake holders,
- Formal technology transfer agreements between the S&T, acquisition, and requirements communities are established regarding technology maturation and program insertion,

- And, a reasonable goal, 80% of all FNC developmental elements, is established for requiring formal agreements.

If the FNCs provide a model for the acquisition of evolutionary technology, the DON still needs a way of fostering the development and acquisition of disruptive technologies.[3]

Disruptive technologies threaten programs of record but are essential to future Naval superiority. The Naval acquisition community structure must provide a home for their development without intimidating the established programs of record.

[3] A disruptive technology is an innovation that leads to new classes of products that are cheaper, better, and more convenient than their predecessors. These products are typically adopted, initially, only by a small, fringe set of users, and rarely emerge in response to customer demand. Disruptive technologies have features that a few fringe (and generally new) customers value. Products based on disruptive technologies are typically cheaper to produce, simpler, smaller, better performing, and, frequently, more convenient to use. A sustaining technology improves the performance of established products. Sustaining technologies are usually developed by successful and well established companies who often hold a leadership position in their industries. (The terms originated with Clayton Christensen, Professor of Business Administration at Harvard Business School.) In this context, the FNCs, as evolutionary programs, are generally in the business of developing sustaining as opposed to disruptive technologies.

Recommendations:

Increase Acquisition Community Confidence in Technology Maturity

- **Further improve technology maturation process:**
  - **Require Acquisition Advocate at TRL 3**
  - **Require Technology Transfer Agreement (TTA) at TRL 4**
  - **Hand-over S&T program oversight & approval to acquisition program at TRL 4**
  - **Review TTAs annually to ensure alignment**
- **Establish technology liaison position/function in acquisition programs where they do not exist**
- **Create Direct Reporting Program Office to manage leap ahead technology to acceptable level of maturity**

Naval Research Advisory Committee

The Panel found that the FNC process could be improved by further expanding the formal agreement process, and by passing oversight of the S&T program to the acquisition community at the appropriate time. Presently the requirements community is the dominant partner in the FNCs, we think this role would be better filled by the acquisition community.

To help eliminate the so-called "Valley of Death," the Panel recommends that 80% of the S&T programs that have matured to TRL 3 (active research and development) should be required to have a formally acknowledged advocate in the acquisition community who needs the technology and endorses further development and maturation. In addition, 80% of all S&T programs should be required to have a signed TTA in place by TRL 4. Furthermore, if an acquisition program assumed oversight of a S&T program at TRL 4 (when components or breadboards are validated in a laboratory environment), the acquisition program would gain intimate knowledge of the technology's development status, rate of maturing, and risk of insertion. To this end, we believe that acquisition community PMs should provide management oversight to S&T programs from TRL4 through formal transition into acquisition programs. When a technology applies to more than one program, a single PM should be given the lead. We recommend that the S&T programs' TTAs be reviewed annually, with progress toward higher TRLs and alignment with evolving requirements receiving particular attention.

The accelerating pace of technological change, the inherent complexities of these technologies, and the multitude of their sources of origin are well beyond the ability of any single acquisition PM to assimilate and act on. In view of this, and with the absolute need to connect acquisition programs of record with Naval S&T, the Panel strongly believes that dedicated "technology finders" or liaison personnel must be established to create the critical bridge to technology hand-over. These acquisition technologists in the program offices would have insight into the problems and opportunities of each program, and help search for

the best science and technology solutions available. These personnel could also manage the related portfolio of science-and-technology-like activities present in every program—like Small Business Innovation Research (SBIR) and Foreign Comparative Test (FCT) programs. For the Systems Commands, an individual technology liaison position could administer a basket of smaller, related programs within a division or product group. They would also be the principal user of the Panel's recommendation below dealing with the creation of a technology knowledge base.

The Panel also notes that "disruptive technology" must be accommodated and managed by the S&T and acquisition communites. These technologies, as opposed to "sustaining technology," usually pose too high a risk to an established program of record. (They frequently become available at what is usually an unacceptably low TRL, say TRL 3 or 4.) However, disruptive technologies offer potentially transformational capabilities. We think they should be incubated in some specialized process. The Assistant Secretary of the Navy (Research, Development, and Acquisition) should establish a Direct Reporting Program Manager (DRPM) charged with maturing these disruptive technologies to lower levels of risk so an acquisition program can adopt them. This advocate for disruptive technologies would be charged with taking more risk and so will have certain S&T programs fall by the wayside as they fail to prove useful. But when such programs fail, they would not jeopardize any particular program of record. Without an office of this type, higher risk but potentially important technologies may not be developed because of the threat they pose to established programs' schedules and budgets.

Findings:

Proper use of Metrics and Incentives Improves Results

- **Metrics inspected and incentivized correlate directly with accomplishment**
- **Existing incentives have not been consistently applied to technology insertion**
- **Innovative acquisition strategies can incentivize PMs and industry to increase technology insertion**

Organizations do well what the boss checks and rewards

Naval Research Advisory Committee

In both government and industry, what you inspect and incentivize is what you accomplish. The acquisition reform movement has exhaustively scrutinized contractual and personnel incentives in general. A wide variety of incentives exists, but they generally have not been consistently applied to promote technology acquisition.

The introduction of new technology always carries with it risks to cost, schedule and performance. PMs are understandably risk-averse and so are generally reluctant to be early adopters of a new technology.

The motivation to introduce new technology is generally either to improve performance or reduce cost—normally acquisition cost, sometimes life cycle cost. For acquisition cost, if profit is tied to percentage of the cost of the contract, the contractor has no incentive to reduce cost by technology insertion unless the scope and resources of the base contract are expanded. Similarly, the PM is typically not motivated to reduce program cost because, if the program actually recovers savings, the comptroller normally sweeps them up to fund shortfalls in other programs.

Life cycle cost (LCC) or total ownership cost (TOC) represents the sum of acquisition cost plus operations and support (O&S) costs over the system's service life. Annual O&S cost targets are being introduced in recent Operational Requirements Documents (ORD) (now called "Capability Development Documents" (CDD)) for system acquisitions once the initial cost versus capabilities trade-offs have been determined. This alone would provide an incentive to insert technologies in order to meet stated O&S cost requirements. (Adopting technologies that would reduce manning requirements is one good example.) Once the technology required to achieve LCC targets in the ORD or CDD has been identified, PMs and contractors have little incentive to further reduce LCC through further technology insertion,

since this would almost certainly increase acquisition cost. The situation regarding performance is similar. Technology insertion may be a way of meeting the performance requirements stated in the ORD or CDD, but acquisition cost limits constrain the PMs and contractors from going further.

Innovative competitive acquisition strategies and contract clauses can give PMs and industry incentives to increase technology acquisition. Recent examples include the Acoustic Rapid Commercial-off-the-shelf Insertion (ARCI) program, DD21 (now DD(X)), and Joint Strike Fighter (JSF) programs. The goal of the submarine ARCI program is to improve the U.S. Submarine Force's ability to detect hostile submarines at greater ranges. This program is using open software architectures and innovative competitive procurement strategies. The DD(X) and JSF programs have developed some very innovative contractual approaches that offer incentives to both PMs and contractors to insert technology.[4]

Metrics can be used to enhance the transfer of new technology from the S&T community to the acquisition community if criteria are defined and the results reported and tracked. Today, there is no requirement that S&T projects below TRL 4 have advocates in the acquisition community. Currently, TTAs are signed between the S&T community and the acquisition community for 80% of the projects within each FNC program when these projects reach TRL 4. There is no requirement for such agreements in exploitation and deployment projects outside the FNCs.

[4] Naval Research Advisory Committee Report, *Life Cycle Technology Insertion* (July 2002).

NRAC

Recommendations:

Employ Metrics and Incentives to Drive Behavior and Culture Change

- **Insure that each S&T project has an acquisition advocate at TRL 3**
  - **Cancel projects that don't**
- **Insure that S&T projects have a signed TTA at TRL 4**
  - **Cancel projects that don't**
- **Require that acquisition strategy and acquisition plans identify technology transfer incentives and corresponding metrics**
- **Require that a technology insertion plan be criterion for contract award**
- **MDAs establish an exit criterion which identifies the TTA accomplishments required to proceed to the next program phase**
- **Require that both military and civilian performance evaluations include success in technology acquisition/insertion**

Naval Research Advisory Committee

The Assistant Secretary of the Navy (Research, Development and Acquisition) should direct that metrics be established to promote technology acquisition. Each S&T project, whether or not it directly supports an FNC, should be required to identify an acquisition advocate—an acquisition PM—when it reaches TRL 3. Projects not endorsed by the acquisition community at TRL 3 should be cancelled, except in extraordinary circumstances. Additionally, 80% of all S&T projects must be required to have a signed TTA at TRL 4. Currently, only projects supporting a FNC are required to do this. The S&T portfolio should be reviewed annually to insure that its programs are meeting this guidance. If this practice were adopted across the exploitation and deployment portion of the Naval science and technology portfolio, leaders in the DON would have the information they needed to take action if program goals were not being met.

Both contractual and personnel incentives are required to temper the risk-averse PM and contractor culture and enhance technology acquisition. An example of contractual incentives is the "gain sharing" strategy in which a portion of the acquisition cost savings resulting from technology insertion are retained and shared by both the program office and the contractors. In this way, as actual savings occur, part of them could be retained by the program office and used to address other opportunity areas. The contractor could also retain their original negotiated profit plus a share of the savings generated for a net profit gain. Contractual incentives such as this would encourage managed risk-taking. The Panel recommends the following specific actions:

- At program initiation, prior to initial contract award, require that the Program Strategy and Acquisition Plan (AP) specifically identify technology acquisition incentives and the corresponding behaviors and results expected.

- Require that technology acquisition and insertion be an evaluation or source selection criterion.

- Require that Milestone Decision Authorities (MDA) establish an exit criterion at each formal milestone review that identifies the expected TTA accomplishments during the next development phase of a program and include that achievement as a prerequisite for completing the phase being entered.

The DON's military and civilian personnel management systems can also be used to enhance technology acquisition. The performance evaluation system as it stands now assesses performance of duty. When it is understood that technology acquisition is one of Program Officer's or PM's duties, it should be possible to reflect performance of that duty in evaluation reports.

Findings & Conclusions:

T&E Could Yield Large Dividends in Reducing Technology Acquisition Time

- **Testing tends to be serial, redundant, and uncoordinated (Contractor, Development, Operational)**
- **T&E is focused more on rigid performance specifications than mission capabilities**
- **Spiral development suggests the need for alternative testing approaches**
- **Appropriate integration of modeling & simulation with testing could significantly reduce and focus test requirements**

Panel received widely different views of T&E problems/solutions - but did not have time to conduct a comprehensive assessment

Naval Research Advisory Committee

OPNAV (N76) has expressed concern that 33% of every R&D dollar is spent on test and evaluation, and that this fraction is too high. It also appears that the overall testing cycle from contractor testing through the PM's developmental testing and concluding with Director of Test and Evaluation (DoT&E) operational testing, is too long, redundant, and poorly coordinated. Furthermore, most testing and evaluation are conducted in a serial fashion, where each test starts from the beginning and repeats much of what has already been accomplished.

The Panel heard many different views on the advantages and disadvantages of current processes and methods, but there was general agreement that the present approach is costly and extends the time it takes to transition new technology to the warfighter.

In the area of Test and Evaluation Master Plans (TEMPs), there is a strong perception that these are too focused on specifications. They can be inflexible where they need to adapt to changing requirements and concepts of operations (conops).

Moreover, as the Navy and Marine Corps increasingly embrace spiral development, this testing process could become even more redundant, as tests would presumably have to be repeated in each cycle. Parallel testing of contractor, PM, and DoT&E requirements could help, along with the acceptance of more modeling and simulation as a method of evaluation.

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Recommendations:

Capitalize on Potential T&E Opportunities

- **Task detailed study of DON T&E to review process efficiency and determine if there are redundancies that can be eliminated**
  - **Address findings & conclusions**
  - **Consider recommending OSD responsibility for all T&E oversight and certification be placed under JFCOM as the end user/warfighter to enable**
    - **Joint Focus**
    - **Relevant CONOPS**

Further study is required to determine if redundancy in test and evaluation can be reduced through parallel testing. As joint operations have become the norm, and with Joint Forces Command (JFCOM) now tasked with responsibility for all experimentation, training, exercise coordination, interoperability, force provisioning, and development of war fighting policy, consideration should be given to moving all Defense-level test and evaluation under the leadership of the ultimate customer of technology acquisition for better control and focus.

We recommend a detailed study of Naval test and evaluation to find process efficiencies and identify any redundancies that might be eliminated. In particular, the study should examine policy that would take advantage of parallel testing. As a point of departure, such a study might also examine the benefits of placing responsibility for all Defense-level test and evaluation oversight under some representative of the end user and warfighter. This might promote joint focus and more relevant conops.

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Findings & Conclusions:

Technology Awareness Needed

- **Technology transition opportunities not consistently visible to acquisition programs**
  - **Government + Commercial = $298B/year**
  - **International = $???B/year**
- **Programs lack consistent process to identify technology acquisition opportunities**
- **Accelerating technology development confounds knowledge currency**

Naval Research Advisory Committee

It is extremely difficult for acquisition programs to know about the wide array of Naval S&T programs. The balance of Defense-wide science and technology is even less visible. Other government agencies—like the Department of Energy, NASA, the National Institutes of Health, the Department of Transportation, and the Department of Homeland Security—also develop technologies that may have Naval applications. It is even more difficult for acquisition programs to gain awareness of these technologies. Commercial S&T investment—including both United States and foreign—now far outstrips that of the DoD. Such investment is often proprietary, or otherwise invisible.

The problem of successful technology acquisition is further exacerbated by lack of institutionalized processes to identify technology transition opportunities for the acquisition community. We find, for example, that there is no comprehensive, readily accessible, user-friendly S&T data base. Thus a difficult situation gets worse.

Many search engines are available for mining such a knowledge base, once it is created. For example, the Materials and Structures Branch in Naval Air Systems Command has a comprehensive database under the aegis of the Aerospace Materials Technology Consortium. This is a partnership among academia, industry, and government to describe all the latest materials technologies and processes. The Department of Energy uses search engines to find and evaluate the potential of new technology. Such tools include Vx Insight, Auregin, STARLIGHT, SPIKE, VantagePoint, and ClearForest.

While United States investment in research and development dwarfs that of allied and friendly countries, many of these countries excel in specialized areas. Technologically advanced European, Asian, and Latin American nations have a substantial and growing com-

mercial research and development base, and their constrained defense funding has led them to some innovative technology acquisition strategies that could be useful to the DoD.

Awareness of, and access to, technology from all sources, including international ones, facilitates technology acquisition for new systems at any stage. The problem of knowledge currency is compounded by the increasing number of innovations and technology breakthroughs in ever-decreasing time frames. Technology grows and finds its uses at a geometric rate.

Recommendations:

Technology Transition Candidate Knowledge Base

- **Create a knowledge base of technology development activities**
  - **Tool for acquisition program offices to identify transition opportunities**
  - **Tracks technology development through TRLs**
  - **Attributes defined by PMs**
  - **Created and periodically updated by ONR**
  - **Start with ONR, expand to other DoD, other government, commercial, and foreign activities**

Naval Research Advisory Committee

Data mining is a powerful tool for identifying trends and opportunities. The DON should create and maintain a searchable data base of S&T activities. We could also use such an approach to track the evolution of technologies through TRLs. The customer (the acquisition community, and particularly the PMs) must define the data base's attributes in order to insure its usefulness. The Office of Naval Research is the logical authority to create and maintain such a data base.

The broad scope of technology development activities—military, other government, commercial, and international—makes awareness of technology insertion opportunities a daunting responsibility. If the acquisition community is to recognize such opportunities, it will need technology liaison positions analogous to the operating forces' Naval Research Science Advisors and the Marine Corps Systems Command Liaison Officers. Such positions should be established within larger acquisition program offices, and within the PEOs and SYSCOMs to cover the smaller programs. The technology liaison personnel would track emerging technologies likely to prove relevant to each program of record. Data mining tools (like those created by the Department of Energy), Naval technology experts, ONR Global, and commercial technology surveys could be used as resources. An effective technology liaison as a regular member of the acquisition team should help programs not only to avoid missing opportunities to insert valuable technology, but also to warn them away from relying on immature or inappropriate technologies.

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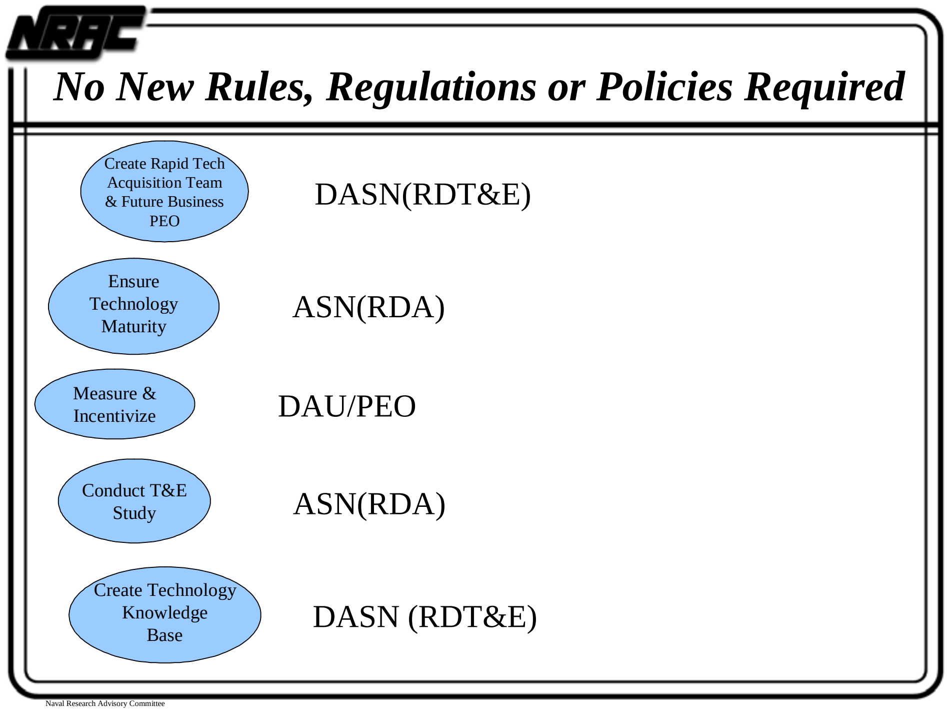

We believe that no new rules, regulations, or policies are required, and we recommend that the following offices be assigned responsibility for implementation.

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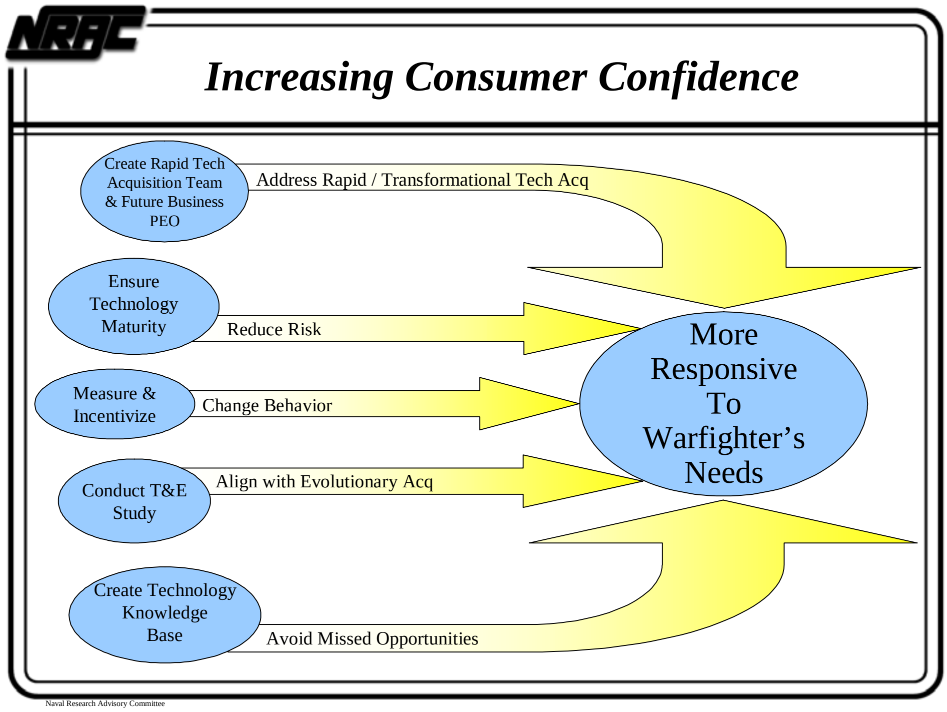

Implicit in Sea Power 21 is an imperative to speed development of new concepts and technologies and to streamline the procedures that facilitate their rapid implementation. The recommendations of this study will shorten the time required to respond to the warfighter's needs.

Institutionalizing the concept of a RTAT would establish an ability to respond rapidly to the warfighter's unique and immediate needs, bypassing the more deliberate acquisition process. The approach the Panel recommends would insure that logistical support is provided and maintained for items delivered through this accelerated process. A Direct Reporting Program Office for Disruptive Technology would incubate promising technologies until they are ready to be handed over to an established program. This office would also provide a home for disruptive technologies emerging from discovery and invention. Since these potentially transformational technologies are not linked to existing acquisition programs, they need an alternative path to maturity.

Requiring an S&T project, whether or not it directly supports an FNC, to identify an acquisition advocate when it reaches TRL 3, and to have a signed TTA at TRL 4, will facilitate a more rapid maturation and acceptance of technology. It would focus resources on S&T that have a customer, and it would give the customer responsibility for program oversight beyond TRL 4. The net result should be a higher yield from the S&T program.

Using established metrics and TRLs to measure a technology's readiness for insertion into acquisition programs will improve the chances of program success. Not only will specific programs benefit, but the consumer's confidence in S&T will also increase, to the general improvement of the research and development culture. Contractual and personnel incentives to temper risk aversion and encourage technology insertion should further improve the

maturation and infusion of technology. The synergy of these initiatives will encourage proper assumption of well-managed risk to meet the needs of the Fleet and Force.

The test and evaluation process is often described as a principal obstacle to rapid handover of technology from acquisition community to the warfighter. In order to be most efficient and effective, the test and evaluation process must complement evolutionary acquisition and spiral development.

A technology knowledge base is essential. The acquisition customers' program is best served if a repository of technology development efforts were available to improve identification of candidates for technology insertion, which in turn may accelerate delivery of mature technology to our Sailors and Marines.

This set of recommendations, if enacted holistically, will result in Naval research enterprise that is held in high esteem and confidence by the acquisition community—the ultimate consumer of S&T. This will help coalesce S&T and acquisition to be even more responsive to the warfighter and help maintain the technology advantage the US enjoys today.

Appendix A

Terms of Reference

Technology Acquisition Reform

Objective

To recommend alternative approaches to technology acquisition that could be implemented within the Department of the Navy's acquisition system.

Background

The acquisition system used by the Department of the Navy (DON) to procure new systems including software and material is mandated by the Department of Defense (DoD). It is an industrial age system being employed in an information age. The goal of the acquisition system is to insure that DON personnel have the best and most reliable sate of the practice hardware and software available to accomplish assigned missions. Because of the complexity of modern day warfare, rate of change of technology, bottom line emphasis by commercial business, as well as regulatory restrictions both internal and external to the DoD, the acquisition system has become cumbersome and excessive.

In addition to being cumbersome the cost of administration of the acquisition system is of major concern both for government and industry alike. As a result of the cost and complexity of maintaining a unique DoD acquisition system, there are commercial companies who will not seek defense contracts. This has the potential of denying the latest technology to operational forces.

Finally, the cost of administration has to be measured in the currency of both money and time. The Milestone Decision Authorities must spend considerable time reviewing the necessary information and documentation to insure that the acquisition decisions are compliant to regulations. In many cases the reviews are quickly rendered useless by changes in a program, which requires new documentation.

Finally, the Chief of Naval Operations has promulgated the strategy of *Seapower 21*. One of tenets of *Seapower 21* is to speed development of new concepts and technologies. In order for those new concepts and technologies to quickly reach the intended operating forces there must be streamlined procedures that facilitate rapid implementation.

Specific Tasking

This NRAC study will examine current approaches to managing DON acquisition programs with a particular emphasis on technology acquisition. This study will also examine alternative approaches tested by other departments, agencies, and countries. Specifically, this NRAC study will:

- Review examples of new, emerging, and experimental technology acquisition. For example, NMCI lessons learned, CTTO lessons learned, In-Q-Tel, Army venture fund, DoD and Navy venture fund plans, UK R&D privatization.

- Investigate acquisition alternatives studied by ATL, and others.
- Recommend procedures and opportunities to streamline and improve technology acquisition subject to regulatory restrictions.

Appendix B

Technology Readiness Levels

Technology Readiness Levels, long in use at the National Aeronautics and Space Administration (NASA), have recently been adopted across the Department of Defense. NASA describes them as "a systematic metric/measurement system that supports assessments of the maturity of a particular technology and the consistent comparison of maturity between different types of technology." NASA Management Instruction (NMI 7100) formally incorporates TRLs into integrated technology planning (John C. Mankins, Advanced Concepts Office, Office of Space Access and Technology, NASA, 6 April 1995).

TRL 1: Basic principles observed and reported. Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties.

TRL 2: Technology concept and/or application formulated. Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there is no proof or detailed analysis to support the assumption. Examples are still limited to paper studies.

TRL 3: Analytical and experimental critical function and/or characteristic proof of concept. Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.

TRL 4: Component and/or breadboard validation in laboratory environment. Basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of "ad hoc" hardware in a laboratory.

TRL 5: Component and/or breadboard validation in relevant environment. Fidelity of breadboard technology increases significantly. The basic technological components are integrated with realistically realistic supporting elements so that the technology can be tested in a simulated environment. Examples include "high fidelity" laboratory integration of components.

TRL 6: System/subsystem model or prototype demonstration in a relevant environment. Representative model or prototype system, which is well beyond the breadboard tested for TRL 5, is tested in a relevant environment. Represents a major step in a technology's demonstrated readiness. Examples include testing a prototype in a high fidelity laboratory environment or in simulated operational environment.

TRL 7: System prototype demonstration in an operational environment. Prototype near or at planned operational system. Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in an operational environment, such as in an aircraft, vehicle, or space. Examples include testing the prototype in a test bed aircraft.

TRL 8: Actual system completed and “flight qualified” through test and evaluation. Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.

TRL 9: Actual system “flight proven” through successful mission operations. Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this is the end of the last “bug fixing” aspects of true system development. Examples include using the system under operational mission conditions.

Appendix C

Research, Development and Evaluation Budget Activities

Budget activities 1, 2, and 3 comprise Science and Technology. Budget activities 4, 5, 6, and 7 form that portion of Research Development and Evaluation that belong to the Acquisition system. These seven budget categories are commonly referred to as, respectively, "6.1, 6.2, 6.3, 6.4, 6.5, 6.6, and 6.7."

The following definitions of Research Development and Evaluation Budget Activities are taken from the Department of Defense Financial Management Regulation (DoD 7000.14-R) Volume 2B, Budget Formulation and presentation, Chapter 5, Research, Development and Evaluation Appropriations, 24 June 2002.

Budget Activity 1, Basic Research. Basic research is systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards processes or products in mind. It includes all scientific study and experimentation directed toward increasing fundamental knowledge and understanding in those fields of the physical, engineering, environmental, and life sciences related to long-term national security needs. It is farsighted high payoff research that provides the basis for technological progress. Basic research may lead to: (a) subsequent applied research and advanced technology developments in Defense-related technologies, and (b) new and improved military functional capabilities in areas such as communications, detection, tracking, surveillance, propulsion, mobility, guidance and control, navigation, energy conversion, materials and structures, and personnel support. Program elements in this category involve pre-Milestone A efforts.

Budget Activity 2, Applied Research. Applied research is systematic study to understand the means to meet a recognized and specific national security requirement. It is a systematic application of knowledge to develop useful materials, devices, and systems or methods. It may include design, development, and improvement of prototypes and new processes to meet general mission area requirements. Applied research translates promising basic research into solutions for broadly defined military needs, short of system development. This type of effort may vary from systematic mission-directed research beyond that in Budget Activity 1 to sophisticated breadboard hardware, study, programming and planning efforts that establish the initial feasibility and practicality of proposed solutions to technological challenges. It includes studies, investigations, and non-system specific technology efforts. The dominant characteristic is that applied research is directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters. Applied Research precedes system specific research. Program control of the Applied Research program element is normally exercised by general level of effort. Program elements in this category involve pre-Milestone B efforts, also known as Concept and Technology Development phase tasks, such as concept exploration efforts and paper studies of alternative concepts for meeting a mission need.

Budget Activity 3, Advanced Technology Development (ATD). This budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment. ATD includes concept and technology demonstrations of components and subsystems or system models. The models may be form, fit and function prototypes or scaled models that serve the same demonstration purpose. The results of this type of effort are proof of technological feasibility and assessment of subsystem and component operability and producibility rather than the development of hardware for service use. Projects in this category have a direct relevance to identified military needs. Advanced Technology Development demonstrates the general military utility or cost reduction potential of technology when applied to different types of military equipment or techniques. Program elements in this category involve pre-Milestone B efforts, such as system concept demonstration, joint and Service-specific experiments or Technology Demonstrations. Projects in this category do not necessarily lead to subsequent development or procurement phases.

Budget Activity 4, Advanced Component Development and Prototypes (ACD&P). Efforts necessary to evaluate integrated technologies, representative modes or prototype systems in a high fidelity and realistic operating environment are funded in this budget activity. The ACD&P phase includes system specific efforts that help expedite technology transition from the laboratory to operational use. Emphasis is on proving component and subsystem maturity prior to integration in major and complex systems and may involve risk reduction initiatives. Program elements in this category involve efforts prior to Milestone B and are referred to as advanced component development activities and include technology demonstrations. Completion of Technology Readiness Levels 6 and 7 should be achieved for major programs. Program control is exercised at the program and project level. A logical progression of program phases and development and/or production funding must be evident in the FYDP.

Budget Activity 5, System Development and Demonstration (SDD). SDD programs have passed Milestone B approval and are conducting engineering and manufacturing development tasks aimed at meeting validated requirements prior to full-rate production. This budget activity is characterized by major line item projects and program control is exercised by review of individual programs and projects. Prototype performance is near or at planned operational system levels. Characteristics of this budget activity involve mature system development, integration and demonstration to support Milestone C decisions, and conducting live fire test and evaluation (LFT&E) and initial operational test and evaluation (IOT&E) of production representative articles. A logical progression of program phases and development and production funding must be evident in the FYDP consistent with the Department’s full funding policy.

Budget Activity 6, RDT&E Management Support. This budget activity includes research, development, test and evaluation efforts and funds to sustain and/or modernize the installations or operations required for general research, development, test and evaluation. Test ranges, military construction, maintenance support of laboratories, operation and maintenance of test aircraft and ships, and studies and analyses in support of the RDT&E program are funded in this budget activity. Costs of laboratory personnel, either in-house or contractor operated, would be assigned to appropriate projects or as a line item in the Basic Research,

Applied Research, or Advanced Technology Development program areas, as appropriate. Military construction costs directly related to major development programs are included.

Budget Activity 7, Operational System Development. This budget activity includes development efforts to upgrade systems that have been fielded or have received approval for full rate production and anticipate production funding in the current or subsequent fiscal year. All items are major line item projects that appear as RDT&E Costs of Weapon System Elements in other programs. Program control is exercised by review of individual projects. Programs in this category involve systems that have received Milestone C approval. A logical progression of program phases and development and production funding must be evident in the FYDP, consistent with the Department’s full funding policy.

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Appendix D

Glossary

Acquisition. The conceptualization, initiation, design, development, test, contracting, production, deployment, logistic support, modification, and disposal of weapons and other systems, supplies, or services (including construction) to satisfy DoD needs, intended for use in or in support of military missions.

Acquisition Category (ACAT). ACAT I programs are Major Defense Acquisition Programs (MDAPs). An MDAP is defined as a program estimated by the Under Secretary of Defense (Acquisition, Technology and Logistics) (USD(AT&L)) to require eventual expenditure for research, development, test, and evaluation of more than $365 million (fiscal year (FY) 2000 constant dollars) or procurement of more than $2.19 billion (FY 2000 constant dollars), or those designated by the USD(AT&L) to be ACAT I. ACAT I programs have two sub-categories:

- ACAT ID for which the Milestone Decision Authority (MDA) is USD(AT&L). The 'D' refers to the Defense Acquisition Board (DAB), which advises the USD(AT&L) at major decision points.
- ACAT IC for which the MDA is the DoD Component Head or, if delegated, the DoD Component Acquisition Executive (CAE). The 'C' refers to Component.

The USD(AT&L) designates programs as ACAT ID or ACAT IC.

ACAT IA programs are Major Automated Information Systems (MAISs) or programs designated by the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence (ASD(C3I)) to be ACAT IA. A MAIS is an Automated Information System (AIS) program that is (1) designated by the ASD(C3I) as a MAIS, or (2) estimated to require program costs in any single year in excess of $32 million (FY 2000 constant dollars), total program in excess of $126 million (FY 2000 constant dollars), or total life cycle costs in excess of $378 million (FY 2000 constant dollars). MAISs do not include highly sensitive classified programs (as determined by the Secretary of Defense) or tactical communication systems.) For the purpose of determining whether an AIS is an MAIS, the following shall be aggregated and considered a single AIS: (1) the separate AISs that constitute a multi-element program; (2) the separate AISs that make up an evolutionary or incrementally developed program; or (3) the separate AISs that make up a multi-component AIS program. ACAT IA programs have two sub-categories:

- ACAT IAM for which the MDA is the Chief Information Officer (CIO) of the Department of Defense (DoD), the ASD(C3I). The 'M' (in ACAT IAM) refers to Major Automated Information System (MAIS).
- ACAT IAC for which the DoD CIO has delegated milestone decision authority to the CAE or Component CIO. The 'C' (in ACAT IAC) refers to Component.

The ASD(C3I) designates programs as ACAT IAM or ACAT IAC.

ACAT II programs are defined as those acquisition programs that do not meet the criteria for an ACAT I program, but do meet the criteria for a major system. A major system is defined as a program estimated by the DoD Component Head to require eventual expenditure for research, development, test, and evaluation of more than $140M in FY2000 constant dollars, or for procurement of more than $660M in FY2000 constant dollars or those designated by the DoD Component Head to be ACAT II. The MDA is the DoD CAE.

ACAT III programs are defined as those acquisition programs that do not meet the criteria for an ACAT I, an ACAT IA, or an ACAT II. The MDA is designated by the CAE and shall be at the lowest appropriate level. This category includes less-than-major AISs.

ACAT IV (Navy and Marine Corps only) ACAT programs in the Navy and Marine Corps not otherwise designated as ACAT I, II or III are designated ACAT IV. There are two categories of ACAT IV programs: IVT and IVM. ACAT IVT programs require operational test and evaluation while ACAT IVM programs do not.

Acquisition community. Within the Department of the Navy, those offices responsible for developing and acquiring systems. The acquisition community includes Program Executive Offices, Direct Reporting Program Offices, and Systems Commands. This community is responsible for Budget Activities 4 through 7. The term is also often used in an extended sense to include contractors working for those Naval offices.

Acquisition Decision Memorandum (ADM). A memorandum signed by the milestone decision authority (MDA) that documents decisions made as the result of a milestone decision review, decision review, or interim progress review.

Direct Reporting Program Manager. A Program Manager who reports directly to the Assistant Secretary of the Navy (Research, Development and Acquisition) as opposed to a Program Executive Office.

Disruptive technology. An innovation that leads to new classes of products that are cheaper, better, and more convenient than their predecessors. They are typically adopted, initially, only by a small, fringe set of users, and rarely emerge in response to customer demand. The term originated with Clayton Christensen, *Professor of Business Administration at Harvard Business School* Disruptive technologies have features that a few fringe (and generally new) customers value. Products based on disruptive technologies are typically cheaper to produce, simpler, smaller, better performing, and, frequently, more convenient to use.

Evolutionary acquisiton. Designated as the preferred (but not only) acquisition approach by DoDI 5000.2. Evolutionary acquisition is an acquisition strategy that defines, develops, produces or acquires, and fields an initial hardware of software increment (or block) of operational capability. It is based on technologies demonstrated in relevant environments, time-phased requirements, and demonstrated manufacturing or software deployment capabilities.

Future Naval Capability (FNC). A science and technology program designed to deliver capabilities desired by the Fleet and Force over the next seven years. Each FNC is approved by the Department of the Navy Science and Technology Corporate Board (the Assistant Secretary of the Navy (Research, Development, and Acquisition), the Vice Chief of Naval Operations, and the Assistant Commandant of the Marine Corps) and directed by an Inte-

grated Product Team (IPT) whose members are drawn from the requirements, acquisition, science and technology, and operational communities. The IPT identifies enabling capabilities within the FNC, and then gaps within those enabling capabilities. The science and technology community representative develops and manages a technical program to fill the capability gaps identified by the IPT. When the technologies are sufficiently mature, they transition to an acquisition program.

Future Years Defense Plan (FYDP). The Future Years Defense Plan reflects the decisions associated with the three phases of the PPBS.

Integrated Product Team. Team composed of representatives from appropriate functional disciplines working together to build successful programs, identify and resolve issues, and make sound and timely recommendations to facilitate decision making. There are three types of IPTs: overarching IPTs (OIPTs) that focus on strategic guidance, program assessment, and issue resolution; working level IPTs (WIPTs) that identify and resolve program issues, determine program status, and seek opportunities for acquisition reform; and program level IPTs that focus on program execution and may include representatives from both government and after contract award industry.

Major Defense Acquisition Program (MDAP). An acquisition program that is not a highly sensitive classified program (as determined by the Secretary of Defense) and that is designated by the Under Secretary of Defense (Acquisition, Technology and Logistics) (USD(AT&L)) as an MDAP, or estimated by the USD(AT&L) to require an eventual total expenditure for research, development, test and evaluation (RDT&E) of more than 365 million in fiscal year (FY)2000 constant dollars or, for procurement, of more than 2.19 billion in FY2000 constant dollars.

Milestone. The point at which a recommendation is made and approval sought regarding starting or continuing an acquisition program, i.e., proceeding to the next phase. Milestones established by the release of DoDI 5000.2 are: MS A, that approves entry into the Concept and Technology Development phase; MS B, that approves entry into the System Development and Demonstration phase; and MS C, that approves entry into the Production and Deployment phase. Also of note is the Full Rate Production Decision Review at the end of the Low Rate Initial Production work effort of the Production and Deployment phase. It authorizes full rate production and approves deployment of the system to the field or fleet.

Milestone Decision Authority (MDA). The individual designated in accordance with criteria established by the Under Secretary of Defense (Acquisition, Technology and Logistics) (USD(AT&L)), or by the Assistant Secretary of Defense (Command, Control, Communications, and Intelligence) (ASD(C3I)) for automated information system (AIS) acquisition programs, to approve entry of an acquisition program into the next phase. (DoDI 5000.2)

Planning, Programming and Budgeting System (PPBS). The primary resource allocation process of DoD. One of three major decision making support systems for defense acquisition. It is a formal, systematic structure for making decisions on policy, strategy, and the development of forces and capabilities to accomplish anticipated missions. PPBS is a cyclic process containing three distinct, but interrelated phases: planning, which produces Defense Planning Guidance (DPG); programming, which produces approved program objec-

tives memorandum (POM) for the military departments and defense agencies; and budgeting, which produces the DoD portion of the President's Budget.

Program Executive Officer (PEO). A military or civilian official who has responsibility for directing several major defense acquisition programs and for assigned major system and non-major system acquisition programs. A PEO has no other command or staff responsibilities within the Component, and only reports to and receives guidance and direction from the DoD Component Acquisition Executive. (DoDD 5000.1)

Program Manager (PM). The individual designated in accordance with criteria established by the appropriate Component Acquisition Executive to manage an acquisition program, and appropriately certified under the provisions of the Defense Workforce Improvement Act. A PM has no other command or staff responsibilities within the Component. (DoDD 5000.1).

Program Officer. A member of the Office of Naval Research who manages science and technology programs using funds from Budget Activities 1, 2, or 3.

Science and technology community. The investors and performers responsible for Budget Activities 1 through 3: basic research, applied research, and advanced technology development. The Office of Naval Research leads the Naval science and technology community.

Spiral development. An iterative process for developing a defined set of capabilities within one increment. This process provides the opportunity for interaction between the user, tester, and developer. In this process, the requirements are refined through experimentation and risk management, there is continuous feedback, and the user is provided the best possible capability within the increment. Each increment may include a number of spirals. Spiral development implements evolutionary acquisition.

Sustaining technology. A technology that improves the performance of established products. Sustaining technologies are usually developed by successful and well established companies who are often seen as holding a leadership position in their industries.

Technology insertion. Introduction of a newly developed or newly available technology into a system at some point in its development of operational life cycle.

Technology transition. Moving technology from one Budget Activity to a higher one.

Technology maturation. Moving technology from one TRL to a higher one.

Technology Transition Agreement. An agreement concluded between a science and technology program and an acquisition program that specifies in terms of TRL and detailed cost, schedule, and performance metrics, the conditions under which an acquisition program agrees to accept a technology developed in a science and technology program.

Technology transfer. Moving technology among government and industrial users or producers.

Transformational technology. A technology that introduces a radically new capability that renders classes of existing platforms, systems, or conops obsolete.

Appendix E

References

The National Defense University's research librarians compiled the following summaries of reports done since 1997 that bear on the topic of technology acquisition.

Center for Naval Analyses Reports

Getting the Most Out of Integrated Product Teams (IPTs) (Center for Naval Analyses, CRM-96-49-1 0 October 1996). The report recognizes differences between industry and government IPTS that may make it more difficult to implement EPTs in the Dept of Navy including:

Chain of command considerations that hamper free and open discussion.

- Inability to fully empower government comptrollers.

It recommends:

- Providing guidance and boundaries. Team requirements and authorities should be clear.
- Provide initial awareness/orientation training and just-in-time team-building and special skills training.
- Using full-time and collocated IPTs that will be linked to organizational change and institutionalized rather than operating in "meetings only" mode.
- The broad plan for IPTs should avoid diluting functional expertise by considering: a. The impact on functional organizations.
- The need to retain core capabilities.
- The need to continually develop the workforce and retain critical skills.
- The need to maintain a "corporate memory" of lessons learned.
- Continually reinforce the need for teaming and teamwork by recognizing rewarding and publicizing good examples and good results.
- Restructure IPTs if their size limits their effectiveness by: breaking large IPTs into smaller IPTs, limiting attendance to one representative from each functional organization represented on the team, using one representative empowered to represent more than one functional organization, reassessing the need for representatives from oraanizations whose possible contributions during some program phases may be minimal.

The Revolution in Business Affairs: Realizing the Potential (Center for Naval Analysis Corporation 1998 Annual Conference, Conference Summary). This conference featured several prominent speakers such as John White, Jacques Gansler, John Harare, and Jerry Hultin. The Revolution in Business Affairs (RBA) includes many initiatives such as competitive sourcing, acquisition reform, electronic markets and activity-based costing. The goal is to streamline business practices within the Department of Defense. The conference explored

such topics as defining the RBA, assessing its usefulness, government culture, and implementing the RBA. There are no overall recommendations, but the following provides a brief summary of the conference proceedings. There were individual speakers, and several panel discussions. In one session, six military leaders discussed their views of the Revolution in Business Affairs. They agreed on four actions that senior leaders could take to ensure the success of the RBA. These were:

- Defining goals.
- Setting the organizational climate.
- Ensuring that RBA initiatives provide the right incentives.
- Once the plan is in place, get out of the way.

Several officials from the Reagan and Bush administrations spoke on the successes and failures of previous reform efforts. Some of the "lessons learned" are listed below.

- Inclusion of DoD top management is critical.
- Expect internal resistance.
- The cooperation and support of Congress are important.
- Progress will be slow.

Several participants addressed the role of competition and outsourcing in the RBA. Much of the discussion concerned the A-76 process. Acquisition reform was another major topic. Stan Soloway (the Deputy Under Secretary of Defense for Acquisition Reform) discussed the three elements of successful acquisition reform: focus more on improved performance, effective communication, and flexibility. Other speakers discussed individual program efforts (such as the Apache helicopter) and agency efforts (DLA, Navy, Air Force).

The discussion on cost control centered on: Visibility and Management of Operating and Support Costs (VAMOSC) Activity-Based Costing/Management (ABC/MO Earned Value Management (EVM).

Cheryl Kandaras Chapman led a discussion on improving Congressional support. She suggested four questions to consider for discussion: What are the perceptions of barriers to cooperation? What are the realities of barriers to cooperation? What are our definitions of success? What is the effect on uniformed and civilian personnel?

In the final session, conference participants considered a future scenario where none of the reform efforts were ever put into place. The question is "How did this happen, and how can we prevent it from happening?" Some of the speakers believed that there was not enough of a crisis situation to motivate change. Others cited budget problems or Congress as a hindrance to reform. All agreed on strong leadership to gain Congressional support and begin the reform process.

Congressional Research Service Summaries

Navy-Marine Corps Tactical Air Integration Plan: Background and Issues for Congress (Christopher Bolkcom and Ronald O'Rouke. CRS RS21488, 10 April 2003). This report gives background and issues for Congress on the implementation of a Navy-Marine Corps Tactical Air Integration (TAI) plan that would manage Navy and Marine Corps strike fighters as a common pool of strike fighters. Issues for Congress:

- Total Department of the Navy (DoN) strike fighter capability is questioned.

  — Will numerically smaller but improved TAI force be able to fight and win two overlapping regional conflicts?

  — Does "enhanced funding" mean increased funding or increased likelihood of funding? If increase in funding is less than DoN believes, will TAI force provide the same capability?

  — Will improvements to aircraft capability really make it more effective than the previously planned force? How do you quantify this improvement?

  — The TAI plan would require cross-training of Navy and Marine Corps pilots. What effect would it have on pilot training loads or the ability of pilots to achieve high levels of proficiency in specific mission areas?

- Cost effectiveness may be lower due to:

  — Reductions in strike fighter procurement ($1B) may be offset by increases in aircraft operation and maintenance costs ($3.7B).

  — Increased spending for modernization and ancillary equipment.

  — Increased unit Joint Strike Fighter (JSF) procurement costs because of lower production economies.

- Implications for future aviation integration:

  — The Marine Corps by law is to be a combined-arms force that includes its own aviation assets. TAI plans appear a step towards turning Marine fixed-wing aircraft over to the Navy.

  — TAI plan may renew discussion on cost effectiveness of maintaining separate aviation components.

Defense Acquisition Reform: Status and Current Issues (Valerie Bailey Grasso, CRS IB96022, 8 November 2001). The post-Cold War period necessitated defense acquisition reform, and this report presents a brief history and general overview of those measures. In general, the goals are to the make the Department of Defense (DoD) acquisition system:

- More cost effective.

- Interactive with commercial industries.
- Committed to procuring state-of-the-art technology on a timely basis.

The report then lists major acquisition issues for the 104th, 105th, and 106th Congresses. The three focus areas for the 104th Congress were:

- Restructuring DoD's acquisition organizations and workforce.
- Outsourcing acquisition-related functions to the private sector.
- Overseeing the progress of the Federal Acquisition Streamlining Act, the Federal Acquisition Reform Act, and other initiatives.

Major issues for the 105th Congress included:

- Reviewing Congressionally mandated reports.
- Integrating the assessments of various defense panels.
- Assisting DoD in implementing acquisition workforce reductions.

The 106th Congress had an important oversight role in defense acquisition reform, especially in monitoring DoD reports to Congress.

This report does not make specific recommendations.

Defense Science Board Reports

Report of the Defense Science Board Task Force on Acquisition Reform Phase IV (July 1999). This paper provides metrics, structured in four tiers, to help assess departmental progress in acquisition reform.

- Tier I: Establish a superior military capability matched to the security objectives of the nation. Acquire superior forces at a reasonable cost. A future defense strategy guides resource allocation and management decisions. Measure our forces against threat scenarios with simulations, war games, and actual conflict results. Measure annual cost to sustain United States military objectives (track DoD budget) to ensure reasonable cost.
- Tier II: Choosing the "right" things to acquire. Increase the mission CINC's role in resource allocation. Use the user-supplier resource balance matrix to track programs and resources.
- Tier III: Acquire things of value with speed, efficiency, effectiveness and reduced total ownership costs. For speed—measure time from program initiation to initial operational capability (IOC) and cycle time for system upgrades and modifications. For effectiveness and efficiency—measure the percentage of programs and contracts using performance specifications without detailed statements or specification and contracts using price-based acquisition and measure amount of military and commercial production integration occurring by sector. For reduced ownership costs—measure five programs that make total ownership costs or life cycle cost a requirement, sys-

tems that effectively track total ownership costs and benchmarks to best in class.

- Tier IV: Maintain the public trust. Broaden the use of competition tracking dollar value of investment programs and fielded systems. Establish the value of things to be acquired through user involvement. Depend on competitive market forces. Assess public perception of the acquisition process.

Report of the Defense Science Board Task Force on Vertical Integration and Supplier Decisions (May 1997). This report recommends:

- Expand the Department's monitoring of vertical supply relationships for selected important defense products and technologies.

- Focus DoD acquisition and technology strategies and investments to support competition and innovation.

- During antitrust reviews, continue to scrutinize carefully the potential harms from vertical integration.

- Strengthen business- and industry-related skills of the Department's acquisition personnel.

- Develop measures that help DoD managers to recognize areas of potential vertical integration concern and trigger more detailed investigation.

Appendix D to the Report of the Defense Science Board on Defense Acquisition Reform (Phase II) Jet Engine Commercial Practices Panel Final Report (13 May 1994). This report recommends:

- A detailed comprehensive program should be established to convert the military jet engine industry to commercial practices for procuring and supporting mature engine, production, and support programs.

- The Administration, Congress, and the Department of Defense should provide the necessary waivers and exceptions to the various laws, regulations, standards, and specifications that will allow pure commercial practices to be used to procure and support mature military engine production and support programs.

- A joint government and industry team, under the direction of the Deputy Under Secretary of Defense (Acquisition Reform) should be established and funded to implement the program. The team would create a detailed, time-phased plan for commercial practices on current programs (where practical), follow-on procurements of current in-production engines, and on future engines as they complete qualification and enter production. The team would also explore opportunities to implement commercial practices during jet engine development.

Report of the Defense Science Board Task Force on Defense Acquisition Reform (Phase II) (August 1994). The report recommends pilot industry initiatives:

- Develop a funded government-industry program to transition current contracts and programs to a commercial practice basis.

- Extend to the whole of DoD the recent internal Air Force study on streamlined acquisition of microelectronics.

- Use the software acquisition policy recommended by the Defense Science Board (DSB) Task Force on Software as the basis for commercialization in this industrial sector.

- Bring the National Reconnaissance Office (NRO) – Industry Panel studying the use of commercial practices in the DoD space industry to the point of actionable recommendations.

Report of the Defense Science Board Task Force on Acquisition Reform Phase IV Subpanel on Research and Development (July 1999). After assessing Acquisition Reform Initiatives, the Task Force recommends that implementation of the Price-Based Acquisition Model as the principal method for development and procurement of DoD systems. The Task Force also examined specific programs and made additional recommendations as follows:

- Joint Strike Fighter—insure continuous competition throughout the procurement and sustainment cycle.

- Shipbuilding—the DD 21 should be the designated model for acquisition reform practices.

- Space—use commercially available capabilities whenever possible. DoD research efforts should focus on military-specific technology not commercially available.

- Joint Tactical Radio Program—define an acceptable technical architecture based on commercial specifications.

- Education and training—responsibility for acquisition education and training should be clarified and strengthened.

Defense Science and Technology—2001 Summer Study (2002). The report provides an overview of science and technology resources within the Department of Defense. The goal is to accomplish transformation of military capabilities, and transition by rapid insertion of technology. “Operational experimentation, spiral development, and rapid evolutionary acquisition” should be used to transform the science and technology environment. The report made further recommendations as follows:

- Maintain current level of science and technology investment.

- New science and technology initiatives to meet four transformational challenges. These are defense against biological warfare, finding difficult targets, decision-making, and enabling high-risk operations.

- Exploit commercial technology.

- Spiral development process—a five-year maximum acquisition time.

- Extensive use of red teams.

- Establish a new technology transition process.

- Accelerate the transition process for joint research and development
- Restructure the Department of Defense laboratories.

Defense Acquisition Reform, Phase III: A Streamlined Approach to Weapons Systems Development, Research and Acquisition. The Application of Commercial Practices (May 1996). The current Department of Defense system is outmoded, and should be replaced with the best commercial practices. Following the Phase I and II reports, the focus of Phase III is on extending best-of-class practices to the research and development stages of acquisition. The Commercial-Style Research and Development Model is the recommended method for doing this.

- Implement commercial practices into the research and development stages of acquisition (based on the American free-market economy).
- Use a phased approach or model to implement best practices and decrease time of acquisition cycle (Commercial-Style Research and Development Model).
- Institutionalized decision-making—the Vice Chair, Joint Chiefs of Staff, as focal point for users (the Services) and Under Secretary of Defense (Acquisition and Technology) as representative for suppliers. They should work together to make the most informed decision.
- Measures to protect Government interests and maintain the public trust include continuous competition, flexible performance contracts, risk reduction phase, and evaluation of past contractor performance.

Report of the Defense Science Board Task Force on Acquiring Defense Software Commercially (June 1994). The report recommends:

- Application of commercial practices to software acquisition.
- A "centralized approach" for greater management control and oversight, with the Under Secretary of Defense (Acquisition and Technology) responsible for software policy and program implementation.
- Formation of an Executive Council, and a supporting "process action team" to implement Task Force recommendations.
- Notable on-going efforts include the Air Force Electronic Systems Command, the Reserve Component Automation System, and the Global Command and Control System.

Report of the Defense Science Board Task Force on Defense Acquisition Reform, Phase I (July 1993). This report recommends a complete overhaul of the Department of Defense acquisition system, to increase efficiency, include state-of-the-art technology, and strengthen the United States industrial base. The Task Force recommends the application of commercial practices to the maximum extent possible, in a manner that continues to maintain the public trust. Recommendations include:

- Move away from the Department of Defense cost-based acquisition system (DFARS 211 relaxes the requirement for cost-based acquisition).

- Broaden procurement of commercial practices.
- Use simplified procurement practices.
- Reduce reliance on cost or pricing data.
- Select specific industrial sectors, and implement commercial practices in those sectors. Bring together the private and public participants within these sectors.
- Select two major Unified Commands and increase their capabilities for technology insertion and requirements definition.
- The first annual report detailing goals, responsibilities, and progress should be ready by January 1994.
- Establish an outside Review Group to provide oversight.
- Establish a comprehensive education program for government, industry, and the public.

General Accounting Office Reports

Defense Acquisitions: Need to Revise Acquisition Strategy to Reduce Risk for Joint Air-to-Surface Standoff Missile (Letter Report, 26 April 2000, GAO/NSIAD-00-75). Recommendations include linking production decisions more closely to knowledge points. The report also recommends moving from an arbitrary production date to ensure that before beginning production the missile design is stable, flight testing establishes the missile's ability to meet performance requirements, and key manufacturing processes are controlled so quality, cost, and volume are proven and acceptable.

Defense Acquisitions: Decisions on the Joint Strike Fighter will be Critical for Acquisition Reform (Testimony, 10 May 2000, GAO/T-NSIAD-00-173). The study recommends continuing the Joint Strike Fighter program in its current definition and risk reduction phase, and delaying the decision to move into engineering and manufacturing until technologies are demonstrated to acceptable levels.

Defense Acquisition: Improved Program Outcomes are Possible (Testimony, 18 March 1998, GAO/T-NSIAD-98-123). Decision-makers must provide incentives to drive behaviors by accepting collective responsibility for incentives that drive behavior, placing a cultural focus on "why"—or the incentives that affect behavior—to complement the "how" (process and control) and the "who" (organization), and accepting that actions taken and decisions made on individual programs communicate the broader message of "what will work" to others in the process. Congress and the Department of Defense can depressurize program launch decisions by relieving the need to overpromise on performance and resource estimates, and can make it acceptable for program managers, once a program is underway, to identify unknowns as high risks so they can be worked on earlier in development. The Secretary of Defense can redefine the point for launching programs as the point at which technology development ends and product development begins. For individual program decisions, the Secretary should send the signals that create incentives for acquisition man-

agers to identify unknowns and ameliorate their risks early in development. Finally, the Secretary should develop a policy that promotes productive supplier relationships and emphasizes the importance of suppliers in improving acquisition outcomes and communicate this policy through acquisition workforce and the defense industry. Specific recommendations to Congress include supporting the Secretary of Defense's efforts to change the environment by changes to the acquisition process that provide incentive for gaining sufficient knowledge at key points in weapon acquisition programs, providing funds to manage technology development efforts outside the bounds of individual programs (if the Secretary of Defense separates technology development from product development), and helping create the right incentives for individual programs by favorably considering the Department of Defense funding requests to mitigate high risks early in a program.

Acquisition Reform: DoD's Guidance on using Section 845 Agreements Could be Improved (Letter Report, 7 April 2000, GAO/NSIAD-00-33). The report recommends that the Secretary of Defense provide updated guidance that lays out conditions for using Section 845 agreements and provide a framework to tailor the terms and conditions appropriate for each agreement. The Secretary should also establish and require the use of a set of metrics, including the number of commercial firms participating in Section 845 agreements, which are measurable and directly related to the agreement. Requirements should be in place in time to assist in deliberations on whether to extend the authority past 30 September 2001.

Defense Acquisition: Best Commercial Practices Can Improve Program Outcomes (Statement/Record, 17 March 1999, GAO/T-NSIAD-99-116). This report is primarily an update on Department of Defense progress toward improving the way it acquires weapon systems. Efforts at systemic change have not been reflected in management and decision-making on individual programs. The report suggests a series of actions aimed at fostering an environment in the Department of Defense that encourages or rewards best practices. This environment must become conducive to adopting best commercial practices for gaining knowledge and assessing risks. Program launch decisions must be relieved of pressure to overpromise on performance and resource estimates. Once a program is underway, participants in the acquisition process must make it acceptable for managers to identify unknowns as high risks so that they can be aggressively worked earlier. Decisions made on individual weapon systems send a strong message about the Department of Defense's definition of success and practices that lead to success.

Best Practices: Better Acquisition Outcomes are Possible if DoD Can Apply Lessons from F/A-22 Program (11 April 2003, GAO-03-645T). This testimony does not make recommendations. It only compares best practices with actual experience of the F/A-22 program. Department of Defense emphasizes the use of evolutionary, knowledge-based acquisitions concepts in the newest acquisition policy. Most Department of Defense programs currently do not employ these practices and, as a result, experience cost increases, schedule delays, and poor product quality and reliability. Leadership commitment and attention to putting the policy into practice for individual programs is needed to avoid the problems of the past.

Defense Reform Initiative: Organization, Status, and Challenges (Chapter Report, 21 April 1999, GAO/NSIAD-99-87). The General Accounting Office assesses progress in the Department of Defense implementation of the Defense Reform Initiative (DRI), a program to establish modern business practices within the Defense acquisition community. The report notes that the DRI has only been in place a short while, and that some progress has been made. The recommendations identify areas for improvement:

- Include other reform efforts.
- Develop an integrated strategy and action plan for managing the DRI.
- Identify funding requirements and target areas for the program.

The report also evaluates the progress of the four DRI pillars. The first pillar is reengineering defense business and support functions by implementing private sector best practices. This includes a wide range of activities, such as the use of paperless contracting, electronic commerce, purchase cards, reengineering the DoD's travel system, and transportation of military members' household goods. While progress has been made, some aspects of this pillar will take several years to complete and will not meet the DRI program milestones.

The second pillar is reorganizing and reducing the size of DoD headquarters and agencies. There has been significant progress. Plans are being developed to meet Congressionally mandated reduction of 25% of headquarters management.

The third pillar, expanding the use of competitive sourcing, has a focus of shifting thousands of government positions to the private sector. The plan includes examining 229,000 positions for possible conversion, which will result in cost savings for the DoD.

The fourth pillar calls for reducing Defense infrastructure, with a focus on conducting two additional Base Realignment and Closure (BRAC) rounds. The BRAC rounds have not been approved by Congress, but other reduction methods are being used, such as agency consolidations, demolition of excess facilities, and privatization of utilities.

Federal Acquisition: Trends, Reforms, and Challenges (Testimony, 16 March 2000, T-OGC-00-7, Statement of Henry L. Hinton, Jr., Assistant Comptroller General, National Security and International Affairs Division. In this prepared statement, Mr. Hinton discusses the changing acquisition environment, recent reform efforts, and explores current and future challenges in federal acquisition. In the current environment, DoD remains the largest purchaser, accounting for about two thirds of all federal contracting dollars. Overall, agencies spend more on services than on equipment and supplies. The acquisition process has become more streamlined, but many problems remain, and the system is still slow and inefficient. Trends include downsizing, privatization, and e-commerce.

The recent history of reform efforts, many initiated in the eighties, shows different programs and legislation that regulated every aspect of the acquisition process.

The result was a complex and unwieldy system little-suited for the commercial business environment. In response, Congress enacted the Federal Acquisition Streamlining Act of 1994 and the Clinger-Cohen Act of 1996. The full effects of these reforms cannot yet be measured.

There are three major challenges facing the government: improving the outcomes of Defense systems acquisitions, acquiring and using information technology, and addressing acquisition workforce issues.

Joint Strike Fighter Acquisition: Mature Critical Technologies Needed to Reduce Risks (GAO-02-39, October 2001). This report assesses critical technologies for the Joint Strike Fighter program. The technologies are not mature (have not been built to size and tested under the conditions of the actual product, and are not ready for integration) and therefore present a high risk to the Joint Strike Fighter program as it moves into the engineering and manufacturing phase. This is also inconsistent with best practices. The report recommends delaying the engineering and manufacturing development until critical technologies are mature.

Best Practices: Taking a Strategic Approach Could Improve DoD's Acquisition of Services (18 January 2002, GAO-02-230). The General Accounting Office studied the purchasing practices of six leading United States companies, including Exxon Mobil, Hasbro, and Merrill Lynch. All of the companies studied had reengineered their purchasing practices and achieved outstanding results. Noting that the Department of Defense has already begun to incorporate commercial best practices, and recognizing the unique differences of the Department of Defense, the report recommends that the Secretary of Defense should evaluate a strategic reengineering approach using corporate practices as a framework for the Defense reengineering effort. Specifically, the Secretary should assess whether current or planned financial management systems can produce the data necessary for analysis, and whether the current organizational structure is adequate and properly used. The Secretary should also assess processes and roles for the most efficient acquisition of services.

Defense Space Activities: Organizational Changes Initiated, but Further Management Actions Needed (18 April 2003, GAO-30-379). The Commission to Assess United States National Security Space Management and Organization (the Space Commission) made recommendations to the Department of Defense in 2001. This report updates and earlier (June 2002) assessment of Defense efforts to implement these recommendations. Several of the original thirteen recommendations have been completed. Important organizational changes include:

- Appointing the Under Secretary of the Air Force also as Director, National Reconnaissance Office.
- Realigning Air Force space activities under one command.
- Creating a separate position of Commander, Air Force Space Command.

Additional recommendations include:

- Develop a national security space strategic plan.

- Establish a strategic approach for space human capital.
- Designate a department-level entity to provide space program oversight and assess progress.

Defense Acquisitions: Assessments of Major Weapon Programs (15 May 2003, GAO-03-476). This is the first of an annual report providing Congressional and Defense decision-makers with a knowledge-based assessment of Defense programs that identifies risks and highlights best practices. Twenty-six major weapons programs are studied. There are no recommendations, but program office comments are included in each individual assessment.

Defense Acquisitions: Factors Affecting Outcomes of Advanced Concept Technology Demonstrations (2 December 2002, GAO-03-52). The Advanced Concept Technology Demonstration (ACTD) program was started by the Department of Defense as a way to get new technologies that meet critical military needs into the hands of users faster and for less cost. The General Accounting Office was asked to examine the Department of Defense's process for structuring and executing ACTDs. Under the ACTD program, a prototype is built and tested under realistic conditions, and then is approved or rejected by the Department of Defense. Use of the ACTD can reduce the time of development from ten to fifteen years, to about two to six years. The study looked at twenty-four projects, and made the following recommendations:

- The Department of Defense should strengthen its criteria for assessing the military utility of ACTD projects.
- Consider ways to ensure funding is provided for acquisitions.
- The Department of Defense should seek input from the Secretary of Defense on whether to transition tested technologies.

Information Technology: DoD Needs to Leverage Lessons Learned from its Outsourcing Projects (25 April 2003, GAO-03-371). The study researched leading commercial practices for the outsourcing of information technology services and published a framework of seven phases that included all of the activities involved in outsourcing. The study then examined whether Defense outsourcing projects were using best commercial practices, and whether these lessons were being shared across the Department of Defense. Recommendations include:

- Establish an electronic tool to "capture" lessons learned from successful information technology outsourcing projects for future reference.
- Incorporated the main elements of a lessons-learned program—collection, verification, storage, and dissemination.
- The Under Secretary of Defense (Acquisition, Technology, and Logistics) and the Assistant Secretary of Defense (Command, Control, Communication, and Intelligence) should work together on this.

RAND Reports

Assessing the Use of "Other Transactions" Authority for Prototype Projects (Giles K. Smith, Jeffrey Drezner, and Irving Lachow, RAND DB-375-OSD, 2002). This study examined 21 projects using the "other transactions" (OT) process and found it provided improved access to important commercial technologies as well as improved efficiencies in conducting technological risky prototype projects. It concluded:

- Segment of major firms that were formerly focused exclusively on commercial projects are now willing to participate in DoD prototype projects because of the freedoms inherent in the OT process.

- Flexibility of the OT process can:

  - Achieve better use of industry resources through innovative business arrangements and project designs.

  - Improve management of risks and uncertainties through freedom to modify the program as it evolves.

  - Achieve better value through cost-sharing and reduction of transaction costs. More effort is being devoted to product and less to process.

- Some risks to the government are incurred due to less access to firms' financial records and ownership of intellectual property but immediate rewards outweigh risks.

Strategic Sourcing: Measuring and Managing Performance (Laura H. Baldwin, Frank A. Camm, and Nancy Y. Moore, Rand DB-287-AF. 2000). A strategic sourcing process links the decisions made during the sourcing process to the strategic goals of the customer organization. The Air Force can adapt commercial firms' practices to improve effectiveness of services acquisition.

Use metrics to focus its limited sourcing resources on activities that appear to offer the highest potential returns in performance and cost improvements. Audits that baseline internal performance and cost and benchmarking studies that identify external capabilities can facilitate this process.

- Use metrics to focus the source selection decision on aspects of performance and cost that best support goals of the Air Force customer organization.

- Use metrics to better manage its relationships with external providers. Air Force can build mutual trust with providers and reduce manpower and other costs of the quality assurance program: use metrics that support strategic goals, set aggressive goals for the metrics, and manage performance through open, frequent communication and problem solving supplemented by longer-term efforts to improve performance

- Use performance metrics to improve the performance of its organic provider organizations. Cross-site and Air Force/extemal, benchmarking studies can

promote sharing of best practices and set performance goals. Tracking performance and holdin- personnel accountable for meeting goals will be necessary. Investment in a commercial management information system or outsourcing data collection to generate desired information on service outputs and processes may be beneficial.

Innovation and Technological Leadership: Fifty Years of Competition in U.S. Aircraft R&D (Rand RB-52. 1999). This research brief summarizes research more fully documented in *The Cutting Edge: A Half Century of U.S. Fighter Aircraft R&D.* Drawing on an extensive historical database spanning the past 50 years of U.S. military aircraft production the authors identified three factors crucial to the success of fighter aircraft R&D: experience, competition and government-supported research. Downsizing in the aerospace industry jeopardizes these factors. Commercial transport development by itself has not historically translated into successful fighter R&D. While the commercial marketplace may be able to develop dual use technologies, it is unlikely to produce methodologies and technologies for radical new developments in military capabilities. It recommends defense planners consider various strategies for maintaining experience and promoting continued competition in the U.S. aerospace industry:

Competitive prototype and technology-demonstration programs

- Further acquisition reform
- Selective exploitation of the commercial industrial base
- Other innovative approaches

The Cutting Edge: A Half Century of U.S. Fighter Aircraft R&D (Mark A. Lorell and Hugh P. Levaux, Rand MR-939-AF. 1998). This book reaches three general conclusions:

- Experience matters, because of the tendency to specialize and thus to develop system-specific expertise.
- The most dramatic innovations and breakthroughs come from secondary or marginal players trying to compete with the industry leaders.
- Dedicated military research and development conducted or directly funded by the United States government has been critical in the development of new higher-performance fighter and bombers

The book recommends defense planners consider various strategies for maintaining experience and promoting continued competition in the U.S. aerospace industry:

- Competitive prototype and technology-demonstration programs
- Further acquisition reform
- Selective exploitation of the commercial industrial base
- Other innovative approaches